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THE HELIOTROPISM OF HYDRA.¹

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I. *Introductory*.—Every observer of *Hydra* is familiar with the fact that the animal possesses considerable power of locomotion, and under certain circumstances may creep restlessly about the aquarium; it is not so generally known that its wanderings, which on superficial examination seem vague and meaningless, are in reality directed towards a definite end, and play an important part in the life of the animal. Trembley observed as long ago as 1791 that the movements of *Hydra viridis* show a definite relation to the source of light (heliotropism), the animal manifesting a marked tendency to collect on the illuminated side of the aquarium. Although this heliotropism is now well known, it has not received the attention it deserves; as far as I know, indeed, nothing has been added to Trembley's account by later observers. I find no mention of the subject in any of the more recent papers on heliotropism, except in Loeb's very interesting work,² and this gives no more than a brief review of Trembley's results. The subject is, however, one of considerable interest for several reasons. *Hydra* is not known to possess any kind of differentiated visual apparatus; the animals can be kept under observation for a long time and their behavior closely studied; the comparison of *H. fusca* with *H. viridis* enables us to determine how the

¹ Read before the American Morphological Society, December, 1890.

² *Heliotropismus der Thiere*. Würzburg, 1890.

movements are affected by the presence of chlorophyll; on account of their slowness, the movements may be accurately followed step by step.

Although the observations recorded in the following pages have occupied my attention at intervals for several years, they are still far from exhaustive, and I offer them only as a beginning. They indicate, however, that the purpose of the creeping movements and the stimuli that call them forth have not hitherto received any satisfactory explanation, and that a number of very interesting physiological questions connected with them have in consequence been overlooked. Since the heliotropic movements are complicated by other actions, I will first describe the general character of the movements as a whole.

II. *General Character of the Movements.*—Marshall has given a very good account of the mode of locomotion of *Hydra*,³ though he makes no attempt at an accurate analysis of the movements, and does not mention heliotropism. I shall therefore treat only of the general character of the movements. The following account applies both to *H. viridis* and to *H. fusca*, unless otherwise stated. In a light of moderate intensity (in a north room) the animals, after wandering more or less irregularly about, gradually collect on the side turned towards the window, usually not far from the surface of the water, though here and there a straggler lags in the background or along the sides of the aquarium. The movements then become less active; the animals may remain for a considerable time with only slight changes of position, and, if the food be abundant, rapidly increase in number by growth and budding. It appears, therefore, that in moderate daylight *Hydra* is positively heliotropic, and its behavior is the same with lamplight, even if it be of very low intensity. If the intensity of the light be increased, a point is ultimately reached at which the action is reversed and the animals move away from the light (*i.e.*, the heliotropism becomes negative), though this action is less striking in its results than the advance movement, since the animals do not collect on the side opposite to the light, but move into the shadow of leaves, etc., or seek the

³ *Zeitschrift für Wiss. Zoologie*, XXXVII., 1882.

bottom. It is, however, difficult to determine the precise character of the negative heliotropism, since it only occurs at an intensity that is unfavorable to the general condition of the aquarium, and thus indirectly injures the Hydras.

Up to this point there is no essential difference in the behavior of the two species, although, as many observers of *Hydra* have pointed out, the movements of *H. viridis* are more rapid than those of *H. fusca*, so that the former species almost invariably leads the march towards the light. If now the aquarium be allowed to stand for a long time undisturbed (the water remaining unchanged, but maintained at a constant level), until the food supply of *Daphnia*, *Cypris*, etc., becomes scanty, a very interesting series of movements may be observed in *H. fusca*. (They are only occasionally performed by *H. viridis*, and never, so far as I have observed, with the same regularity as in the former species.) After a prolonged stay near the surface the animal detaches itself from the the glass, and with tentacles widely outstretched sinks slowly to the bottom, often floating for a time at the surface before the descent. Arrived at the bottom, it slowly crawls once more to the light side, gradually, and with many deviations from the straight course, reascends to the surface, ultimately sinks again to the bottom, and so on. Thus the movements pass through a cycle, extremely variable in its details, but on the whole maintaining the character of a slow and regular rotation. The duration of the cycle is extremely variable; it may be only one or two days, or it may be as many weeks.⁴

What is the use of these movements, and by what stimuli are they called forth?

III. *Purpose and Cause of the Movements.*—It appears to be commonly assumed that *Hydra* moves towards the source of light "for the sake of warmth,"—i. e., that within suitable limits a higher temperature is more agreeable to the animal or more

⁴In order to realize the truth of this description it is necessary to have under observation a large number of individuals in a large aquarium, to which they have become thoroughly accustomed by a residence of weeks or months. Many of my observations have been made on a fraternity of Hydras from five hundred to a thousand strong, all of which had arisen in the aquarium from a group of three or four progenitors, in the course of about two months. In this fraternity the cyclical character of the movements was very marked, and the descent of the animals might be observed almost at any time.

favorable to its physiological processes. Whether the animal has any "preferences" or exercises any conscious choice is an open question; but this question aside, the assumption that it is stimulated to move towards the light by the invisible heat-rays is clearly without foundation. The light, before impinging upon the animal, must as a rule traverse a considerable thickness of water, by which the heat-rays are almost wholly absorbed, and thus rendered inoperative. Experimentally the same result is given as follows: If in the winter season an aquarium be placed close to a north window, in a warm room, the animals collect as usual on the light side, although, as shown by a thermopyle, the other sides may receive a much greater supply of heat-rays. Experiments with Bunsen flames or heated objects placed close to the aquarium and kept in a fixed position for days show no perceptible movement of the *Hydras* towards the source of heat, provided no luminous rays are given off from it. The most convincing evidence is afforded by the behavior of *Hydras* towards rays that have passed through water as compared with rays that have passed through liquids absorbing the same amount of heat but transmitting fewer light-rays. Thus it is easy to arrange an apparatus such that a group of *Hydras* is offered the choice between rays that have passed through water (transparent to the visible rays, but nearly impervious to heat-rays) and a strong solution of iodine which, as shown by the thermopyle, is practically the same as water in respect to the transmission of heat-rays, but absorbs a large proportion of the visible rays. Under these circumstances the *Hydras* invariably move in the direction of the rays that have traversed the water, thus proving that the attractive influence must be exerted by the visible rays.

It is certain, therefore, that notwithstanding their complete lack of definite visual apparatus, both species of *Hydra* are not only very sensitive to the visible rays, but perform definite actions in response to the stimuli afforded by them. It seems certain, also, that the heliotropism cannot have the same part to play as in the life of green plants, since it is not peculiar to the green *Hydra*. In this regard *Hydra* differs strikingly from the Protozoa, in

which, as a rule, it is only the chlorophyll-containing forms that seek the light.

The main purpose of the heliotropic movements, as I am convinced, is simply to place the animals in the position of maximum food supply, and the entire cycle of movements of which heliotropism is a factor may be explained on the same basis. The favorite and usual food of *Hydra* consists of various minute Crustacea,—*Daphnia*, *Cypris*, and other Entomostraca, especially the first named,—though it will readily devour insect larvæ and many other small animals. It is a well-known fact that *Daphnia* and related forms manifest in a high degree a heliotropism of the same character as that of *Hydra*,—*i. e.*, positive in moderate light, negative in strong light,—and it must result from this that so far as the movements of the two animals are determined by light the tendency will be, in the long run, for the *Hydras* to collect in the localities most frequented by their prey. It is impossible to study an aquarium well stocked with the two animals without being struck by the immense advantage secured to the *Hydras* by their position on the illuminated side near the surface. In this region the Crustacea often swim in swarms, darting about through a forest of outstretched *Hydras*, many of which are gorged with food and actively budding, while in other parts of the aquarium both animals are far less abundant. The power of seeking the light, or of avoiding it when too strong, thus confers upon the blind, sluggish *Hydra* a means of pursuing and capturing its active and highly organized prey, and a vague, diffused sensibility to light becomes in this way of vital importance to its possessor, and may be brought under the action of natural selection. It cannot be doubted that individuals possessing a sensibility higher than the average will have a distinct advantage over the others, so that natural selection will tend to perpetuate them. An interesting feature of the case is that the increased food supply directly increases the rate of reproduction,—*i. e.*, by budding,—so that, in the long run, individuals of high sensibility will multiply more rapidly than those of low sensibility, and leave a larger number of descendants in increasing proportion from generation to generation. It may be noted, further, that the

Lamarckian theory would seem to be inapplicable to this case, for it is impossible to suppose that a *Hydra* seeks its prey intentionally. It has no means of ascertaining their whereabouts; there is nothing in the character of the movements themselves to indicate that the heliotropic action is conscious or can be increased by individual effort; the heliotropic action is as marked in the complete absence of crustacean food as when it is present. Regarded simply as a useful reflex action which indirectly affects the rate of increase, and which is shown by observation to vary in different individuals, it would seem to be capable of a complete explanation by natural selection alone.

We may now consider the remaining movements. The upward movement towards the surface is performed by both species, but is more active and effective in *H. viridis*. It seems to be not geotropic, but aërotropic (towards the source of oxygen), as indicated by the following experiment. If a large number of *Hydras* be allowed to collect in the usual position, near the surface, in a small aquarium, and the vessel then be completely filled with water and inverted over a pneumatic trough, the usual relations will be reversed, the air supply coming from below. Under these conditions no definite upward movement takes place, and the contrast with an ordinary open aquarium soon becomes apparent. At first the animals wander indefinitely in all directions. Later they gradually forsake the upper portions of the aquarium, and either crawl downwards towards the lower edge or loosen their attachment and sink to the bottom. The downward movement under these conditions is less definite and rapid than the upward movement under the usual conditions, probably because the supply of oxygen from below is less direct and abundant. The results make it certain, however, that gravity does not determine the movement, and leave little doubt of its aërotropic character. The same conclusion is indicated by the fact that the upward movement is always more pronounced when the water is impure, and when it becomes actually foul the *Hydras* place themselves at the very edge, actually in contact with the air. Whether the aërotropic movement has been acquired primarily for the sake of respiration, or in order to lead the *Hydras* more

certainly to their feeding grounds, it would difficult to determine.

We may finally consider the detachment and descent of the Hydras. For a long time, misled by the usual accounts of the feeding habits, I could find no explanation of this movement. The puzzle was solved, however, by the observation that the Hydras, after descending, usually gorge themselves with the sediment at the bottom,⁵ sometimes to such a degree that the body seems distended almost to bursting, and the animal remains for a long time torpid and half contracted, often lying prone upon the bottom or hanging down limp and motionless from the side of the aquarium. I have repeatedly observed every stage of this process,—the gathering in of the sediment by the tentacles, its slow ingestion in a great lump, and the ultimate discharge of the in nutritious refuse.⁶

Under the microscope the sediment is commonly found to consist of a brownish granular *débris*,—apparently the remains of decayed leaves, etc.,—through which are scattered a few diatoms and numerous minute Infusoria of various species. The sediment is used as food even when the aquarium is abundantly stocked with crustaceans, but under these circumstances the Hydras remain longer at the surface. After the exhaustion of the food-animals—which takes place rapidly when the Hydras become very numerous—the Hydras are compelled to live wholly upon mud, and the cyclical character of the movements becomes more pronounced.

It has been mentioned that the descent of *H. viridis* rarely takes place, and the ingestion of mud by these species has not been observed. This is probably to be explained by the fact that the nutritive processes are aided by the action of the chlorophyll, so that in the absence of crustacean food the advantage of seeking the mud is lessened or counterbalanced by the disadvantage of leaving the illumination most favorable to assimilation. I may

⁵ I have observed this habit only in *H. fusca*.

⁶ Miss Greenwood states (*Journal of Physiology*, Vol. IX., 1888, p. 349) that *Hydra* is essentially carnivorous, and that she has never seen the ingestion of inorganic or in nutritious matter. In my aquaria, however, *H. fusca* has sometimes subsisted for many weeks with no other visible food supply than the sediment.

add that *H. viridis* is far more hardy than *H. fusca*, being able to live for many days or weeks in foul water that would quickly prove fatal to the latter species. This power of endurance may be due to the liberation of oxygen through the assimilative action of the chlorophyll.

En résumé, the movements of *Hydra* may be resolved into three actions, which, taken together, insure to the animal a supply of food and air. These are (1) heliotropism, (2) aërotropism, and (3) detachment from the support; and the three are so combined as to form on the whole a cycle. Each movement appears to be called forth by a particular stimulus,—the first by light-rays, the second by dissolved air, the third apparently by diminished food supply of a certain kind. The entire series of movements is useful to the animal, is in large part even of vital importance, and at first sight gives the general impression of consciousness and design; yet a careful analysis of the action weakens this impression, and indicates that it may be regarded as a series of rather complex reflexes, into which the element of consciousness, and *a fortiori* intelligence, need not enter at all.

We may perhaps push the matter a step further back. Granting that the heliotropism of *Hydra* has been acquired because of the similar heliotropism of *Daphnia*, we may next seek an explanation of the latter action. The explanation lies close at hand, though I have never seen it stated. There can be little doubt that *Daphnia*, like *Hydra*, seeks the light because it there finds the maximum food supply. It is well known that a large number of microscopic green plants possess a considerable power of locomotion, and that they are positively or negatively heliotropic according to the intensity of the light. This is true, for instance, of the zoöpores of numerous species of fresh-water algae, of many desmids, and other forms. These plants form a part—probably an important part—of the food of *Daphnia*, and the animal would accordingly gain a great advantage by acquiring a similar heliotropism. Lastly, the heliotropism of the plants is no doubt a provision for placing them in the optimum position for assimilation. It appears, therefore, that the ultimate reason for the heliotropism of *Hydra* may lie in the mode of assimilation in green plants, and

the case seems to me an interesting one, as illustrating both the correlations between associated organisms, and the nature of the conditions that may enable natural selection to operate at or near the beginning of a series of physiological and morphological modifications.

IV. *Color Discrimination.*—Like many other heliotropic forms, *Hydra* is chiefly affected by the blue rays. If strips of glass of various colors be fastened to the illuminated side of an aquarium, both species of *Hydra* show a very marked tendency to collect under the blue, and an equally marked avoidance of the red, green, yellow, or any combination of colors containing no blue. This preference for the blue is (within rather wide limits) independent of intensity. This is strikingly shown by the comparison of a light "yellow" glass with a dark blue cobalt glass,⁷ the former being of high, the latter of low, intensity. If equal areas on the light side of an aquarium be covered (see Table II.) (a) with yellow, (b) with blue, (c) with an opaque screen, and a fourth area (d) be left uncovered, the result is invariably that in the course of a few days the greatest number of *Hydras* will be found under the blue (allowance being of course made for the initial differences); the uncovered area stands next, and the shaded and yellow areas contain fewest, with no constant difference between them. That is, the areas compare as follows, as regards:

	HIGHEST.	LOWEST.
INTENSITY,	(d) White, (a) Yellow,	(b) Blue, (c) Dark,
ATTRACTIVENESS, (b) Blue,	(d) White,	{ (a) Yellow, (c) Dark.

⁷ The colors of the glasses used in the experiments, as tested by the spectroscope, were as follows:

RED.—Transmits red and a little orange. Complete absorption of the upper end down to a little beyond the D line. Lower end just perceptibly shortened.

YELLOW.—Transmits all but the blue, indigo, and violet. With one layer, complete absorption of upper end down to δ in the green. Red end very slightly shortened. Two layers cut out of the upper end as far as E, but still transmit some green. Three layers produce nearly complete absorption of the green.

GREEN.—Transmits green and yellow. Upper end absorbed down to just below F. Red end nearly absorbed, but a faint band transmitted between B and C.

BLUE.—Transmits blue, indigo, and violet, and a very little green and red. In a single layer upper end transmitted as far as F. Very faint transmission of green between E and F, and a slightly brighter but narrow band to the left of E. A broad but only barely visible band transmitted in the red. Two layers extinguish the red completely and the green nearly. With three or four layers nothing is visible below F.

The same result is reached if two or even three layers of blue glass are used (see Table II.), although in the last case the blue color is so dark that at a short distance it appears nearly opaque to the eye. It is, moreover, immaterial whether the four (three) areas constitute the only source of light (the top and other sides being in this case covered with black paper) or the diffused light of the room enter from behind and above; the result remains the same. Red and green glass agree nearly with yellow, the Hydras treating them practically as if they were opaque. (This statement will require some modification hereafter.)

The result thus obtained is rendered still more striking if the yellow and blue glasses be interchanged. Within an hour or two the Hydras begin to move out of the yellow light and into the blue, and in a day or two, more or less according to circumstances, the numbers under the blue are far in excess. Thus the Hydras may be driven from one area to another and back again by interchanging the glasses, as often as may be desired (see Table III.). For further details the reader is referred to the explanation of the tables and the chart.

The Heliotropism of Hydra.

AREAS	ARRANGEMENT OF THE COLORS	Hour.	Weather.	Temperature, F.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
<i>Date.</i>					<i>B2</i>			<i>B2</i>		<i>R2</i>			
March 9,	10-30 A.M.	Bright.	"	11	17	19	18	9	27	11	25	16	22
" 9,	12-30 P.M.	Cloudy.	"	10	15	18	19	19	17	24	16	25	16
" 10,	10-30 A.M.	Cloudy.	67°	14	8	21	22	23	10	27	9	33	10
" 10,	4-30 P.M.	"	75°	15	7	21	35	24	7	30	7	37	7
" 11,	9-30 A.M.	"	"	14	4	23	30	27	9	25	9	32	9
" 12,	10-30 A.M.	Bright.	74°	21	15	34	29	14	28	5	35	5	35
" 13,	10-30 A.M.	Cloudy.	"	26	6	21	41	20	13	33	8	43	8
" 14,	12-30 P.M.	"	72°	33	8	25	30	31	7	30	5	46	5
REARRANGEMENT OF THE COLORS					B3			B4		B2			
<i>Date.</i>		<i>Hour.</i>	<i>Weather.</i>	<i>Temperature, F.</i>									
March 15,	9-30 A.M.	Cloudy.	70°	21	16	22	21	21	27	18	25	26	26
" 15,	3-30 P.M.	Bright.	70°	15	27	15	26	20	30	11	33	26	26
" 16,	11-30 A.M.	"	62°	17	23	18	22	23	38	15	41	25	25
" 17,	10-30 A.M.	"	70°	21	25	23	17	27	41	20	47	21	21
" 18,	11-30 A.M.	"	68°	13	36	20	22	15	43	14	50	18	18
" 18,	5-00 P.M.	"	68°	13	39	10	21	18	45	14	52	21	21
REARRANGEMENT OF THE COLORS					V			G2		R			
<i>Date.</i>		<i>Hour.</i>	<i>Weather.</i>	<i>Temperature, F.</i>									
March 19,	Noon.	Cloudy.	66°	29	7	34	17	39	24	42			
" 19,	3-45 P.M.	"	"	35	6	33	20	38	17	43			
" 20,	10-00 A.M.	Bright.	72°	36	10	31	19	33	27	53			
" 20,	3-45 P.M.	"	"	39	11	35	14	42	21	63			
" 21,	9-45 A.M.	Foggy.	70°	33	10	41	13	38	20	65			
" 22,	1-00 P.M.	"	66°	35	8	48	17	52	18	64			
" 23,	10-00 A.M.	Cloudy.	64°	34	14	33	25	35	24	58			

EXPLANATION OF TABLE I.

The areas marked I.-IX. were vertical parallelograms of equal size (34 by 125 mm.), extending from the bottom to the surface, consecutively placed on the side of a large square aquarium, which was placed at a distance of fourteen feet from a window three feet wide and eight feet high, facing the northeast, so that direct sunlight never fell upon the aquarium. The top of the aquarium was covered, the ends and rear side uncovered, so as to admit the diffused light of the room. Area IX. extended to within nine mm. of one end of the aquarium. I. was nearly in the middle. The Hydras had lived for about two months in the aquarium, and were very large and vigorous, many of them actively budding. Throughout the experiment there was a moderate supply of crustacean food, but the animals nevertheless often descended to the bottom and filled themselves with sediment. The alternate areas II., IV., VI., VIII., were first covered with double layers of colored glass (for the color-test see page 421), as in the table, and these were allowed to remain for five days. The results were as follows: The total number of Hydras increased from 153 to 215,—i. e., 40 per cent. The record of the colored areas (taking the mean of the first two and the last two observations) was:

Yellow	decrease (per cent.)	56
Red	" "	55
Green	" "	70
Blue	increase "	92

The record of the light areas was:

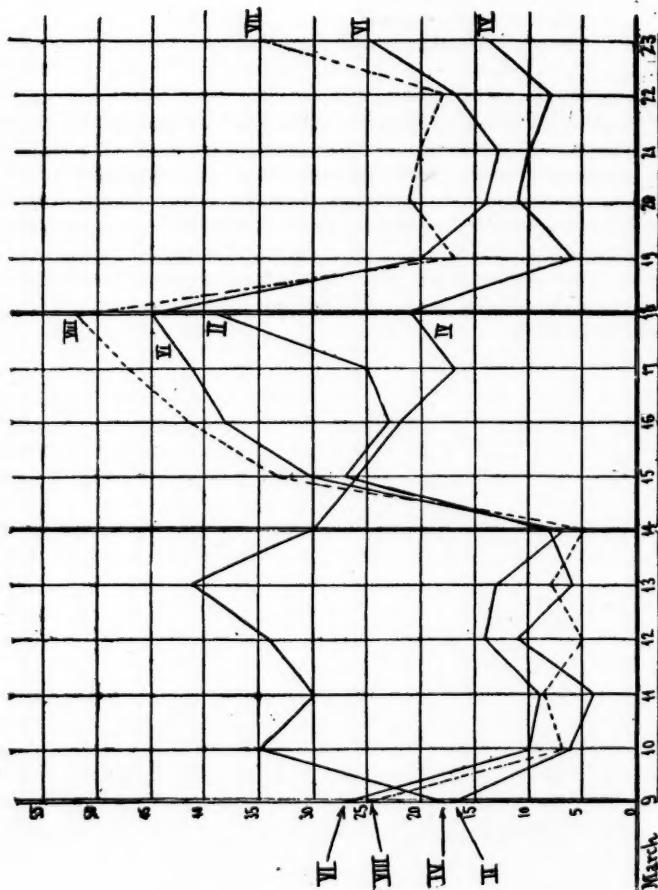
I.	increase (per cent.)	185
III.	" "	24
V.	" "	89
VII.	" "	80
IX.	" "	134

Thus all of the colors except the blue show a large decrease; the blue and all of the light areas a large increase. The increase in the blue is more than double the general rate of increase, but less than that of the two end areas, I. and IX. The colors are now rearranged, one layer of blue being substituted for the green, two layers of blue for the red, three layers of blue for the yellow, and four layers of blue for the former two layers of area IV. Results, after four days, as follows (taking, as before, the mean of the last two observations):

Total increase 215 to 233,— <i>i.e.</i> , eight per cent.
Single blue (after green), . . . increase (per cent.) 692
Double blue (after red) " " 340
Triple blue (after yellow) " " 436
Quadruple blue (after double blue), decrease " 40

Every light area shows a heavy decrease. The experiment seems to show that under the existing conditions the limit of attractiveness, as determined by intensity, lies between three and four layers of blue glass. On replacing the various blues by red, green, and yellow, as in the table, every colored area shows a heavy decrease, and every light area a large increase.

The general result is that, allowing for all variations of weather, temperature, and irregular movements, *H. fusca* shows a very marked "preference" for blue in comparison either with light of other colors or with white light; and an equally marked "preference" for white light as compared with any color except blue.



The above diagram shows in graphic form the same results set forth in Table I. Vertical distances from the base denote the number of Hydras; horizontal distances to the right of the left-hand vertical line denote the date (see Table I.) The colors were changed at the vertical double lines.

The curves show very strikingly, along with the indefinite diurnal fluctuations, the immediate fall in the number of Hydras when placed under any color except blue. The curve IV., as compared with that of II., shows that the attractive influence of blue, under the conditions of the experiment, ceased when the intensity of the blue was diminished beyond three layers of glass.

The comparison of curves II., VI., and VIII. shows a remarkable similarity between them, and indicates that, under the conditions of the experiments, the actions of red, green, and "yellow" did not materially differ.

EXPLANATION OF TABLE II. (page 428.)

This experiment gives a comparison of blue, yellow, white, and the shadow of an opaque screen (II.), and shows the amount of fluctuation from day to day. The general arrangement is the same as in Table I., the same aquarium, Hydras, position, and areas being used as before, but the areas are increased in number, so as to extend over nearly the whole illuminated side, area I. being three mm. from one end, and area XVI. nine mm. from the other. The comparison is made between the first and last observations.

Total increase, 421 to 674,— <i>i.e.</i> , 60 per cent.
Blue, increase 327 per cent.
Yellow, decrease 30 "
Dark screen, decrease 37 "
Light (a mean of V., VI., VII., increase . . 30 "

An inspection of the table shows that although these figures express the broad general result with sufficient accuracy, they are not to be taken to mean more than this, since there is a wide margin of apparently fortuitous variation from day to day. The table shows a marked "preference" for the blue, and a much less marked but still distinct "preference" for ordinary daylight, as compared with the light of diminished intensity behind the opaque screen. The yellow glass acts practically as if it were opaque.

[May]

TABLE II.—*H. fuscata*.

AREAS	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.
ARRANGEMENT																
March 28, 4:30 P.M.	24	14	15	19	26	27	14	22	19	29	24	33	29	34	32	60
" 29, 10:30 A.M.	24	14	29	11	25	26	16	25	16	29	25	29	31	17	45	62
" 29, 4:00 P.M.																
" 30, 9:45 A.M.	17	13	28	13	24	22	25	24	16	29	27	34	34	12	50	73
" 31, 9:30 A.M.	23	13	34	16	22	29	22	30	10	24	33	34	34	16	47	84
April 1, 10:00 A.M.	21	21	34	12	26	27	17	30	14	23	29	34	31	24	55	65
" 2, 11:00 A.M.	18	17	42	19	30	23	22	30	14	22	24	27	43	24	54	73
" 3, Noon.	19	26	42	23	32	27	20	14	19	21	29	31	35	23	53	83
" 4, 10:00 A.M.	14	22	46	25	37	33	14	26	11	19	33	31	45	17	46	78
REARRANGEMENT																
April 4, 1:00 P.M.																
" 4, 4:00 P.M.																
" 4, 8:00 P.M.																
" 5, 10:00 A.M.	21	29	49	28	44	35	17	27	15	18	29	38	47	28	54	77
" 5, 4:00 P.M.																
" 6, 10:00 A.M.	15	39	46	28	39	41	23	38	6	22	23	28	50	19	45	88
" 8, 1:00 P.M.	37	43	38	32	50	39	30	41	9	25	24	38	37	23	53	100
" 9, 4:30 P.M.	40	50	34	37	48	39	33	44	11	21	23	35	44	17	71	83
" 10, 9:30 A.M.																
" 15, 11:00 A.M.	59	52	64	17	25	30	33	43	9	12	33	31	33	43	18	94

TABLE III.—*Hydra viridis*.

AREAS	I.	II.	III.	IV.	V.	VI.	VII.
ARRANGEMENT	G		B		Y		R
March 24, 5.30 P.M.	I	0	6	2	8	2	2
" 24, 8.30 P.M.	I	I	7	6	5	5	1
" 25, 11.45 A.M.	0	0	14	0	0	7	0
REARRANGED	G		Y		B		R
March 25, 2.00 P.M.	0	3	4	5	5	4	0
" 25, 5.00 P.M.	0	5	1	6	6	4	0
" 26, 5.00 P.M.	0	7	3	3	6	6	0
" 27, 4.00 P.M.	0	3	0	4	9	6	2
" 28, 4.00 P.M.	0	3	0	5	9	6	2
" 29, 3.00 P.M.	0	3	0	2	15	4	0
REARRANGED	G		Y		R		B
March 29, 9.45 P.M.	0	4	0	9	6	8	2
" 30, 9.45 A.M.	0	4	0	10	1	6	8
" 31, 9.00 A.M.	0	4	0	12	0	5	9
REARRANGED		B.			B		
March 31, 12.30 P.M.	I	I	7	4	6	6	4
April 1, 9.30 A.M.	5	I	11	2	9	4	4
REARRANGED		B2			B1		
April 2, 10.00 A.M.	5	5	10	0	13	7	6
" 2, 9.00 P.M.	3	2	7	2	19	2	6
" 3, 11.00 A.M.	6	3	3	5	14	6	5

EXPLANATION OF TABLE III.

General conditions of the experiment, as in Tables I., II., but the animals were in a cylindrical aquarium, eight inches in diameter, and the areas were much smaller (colored areas, 20 by 70 mm.; light areas, 10 by 70 mm.). The middle area (IV.) was turned towards the window. The end areas (I., VII.) would therefore tend to receive any Hydras advancing towards the light around the sides.

The results show a complete avoidance of all colors except blue, and a marked "preference" for blue as compared with ordinary daylight.

The results obtained by the use of colored glasses are confirmed by tests with the actual spectrum.⁸ If a spectrum produced by passing a beam of light from an Argand lamp through a prism be thrown upon a group of Hydras, they show a very marked tendency to collect in the lower blue. It is

⁸ For this purpose I have used an Argand gas-burner, the light from which was passed first through a narrow slit, then through a biconvex lens to render the rays approximately parallel, and finally through a large prism (bisulphide bottle). The spectrum thus obtained was projected upon the side of a square aquarium ruled in small squares, and at

difficult to fix exactly the limit of the attractive rays. As nearly as can be determined they extend over the lower third of the blue end,—*i. e.*, from G nearly to F,—and for a short distance into the green.

The results of these experiments leave no doubt that, irrespective of intensity, *Hydra* prefers⁹ blue light to all other colors and to white light (ordinary daylight). My observations indicate further that, although the blue rays are by far the most efficient, a slight attractive influence is also exercised by the green. Under ordinary circumstances—*i. e.*, when diffused daylight is not cut off from behind or above—*Hydra* appears to be as indifferent to green as to red or to an opaque screen. If, however, the animal be enclosed in an aquarium so arranged as to offer it the choice between green and either red or "yellow," a distinct though slight preference is shown for the green, and the animals very gradually accumulate behind it. The green glass used in this experiment shows no trace of blue under the spectroscope. If the choice be offered between red or "yellow" (the latter = red + yellow + green), no perceptible preference is shown, even if the experiment be continued for weeks. This result is of some interest, for it seems to show that the slight attractive influence of green is nullified by the admixture of red and yellow, just as the attractiveness of blue is diminished by the admixture of the other colors, as has been shown.

The preference of *Hydra* for blue as compared with white light is a very remarkable fact; for the animal can never have had any experience of pure blue, but only of white, light,—*i. e.*, blue plus the other colors of the spectrum. Neither can the preference for blue glass be due simply and solely to the attractive influence of the blue rays, for the ordinary daylight entering the aquarium contains at least as many blue rays as the same

the distance adopted (about two feet from the prism) was about three inches in length. The apparatus was placed in a perfectly dark underground room, and every pains was taken, by the use of suitable screens, etc., to exclude from the aquarium all light excepting that proceeding from the prism.

⁹ The word "prefer" is perhaps objectionable as implying an act of consciousness on the part of *Hydra*. I do not wish to make such an implication, however, and use the word only for the sake of brevity.

light after its passage through the blue glass. The conclusion would seem to be inevitable that the lower rays exercise an injurious or repellent action, and thus tend to produce negative heliotropism, or to counteract the effect of the blue rays. It is a tempting hypothesis to suppose that the blue rays are most efficient in light of low intensity, and the lower rays most efficient in high,—a view which would explain in the clearest manner the reversal of heliotropism with the change in intensity. Experiment, however, does not sustain this conclusion, but indicates that the animal is wholly indifferent to the lower rays. Hydras supplied only with light that has passed through red or yellow glass do not noticeably move either away from or towards it, but behave as though the glass were opaque. Tested with the actual spectrum, they appear to be quite indifferent to all of the rays except the lower blue and the upper green. I have also tested this question by the comparison of nearly pure blue glass with purple (aqueous solutions of methyl-violet of various intensities), which is a mixture of blue and red. Any repellent action on the part of the red might reasonably be expected to counteract more or less completely the attractiveness of the blue. Experiment shows, however, that purple is as attractive as pure blue,—neither more nor less, as far as can be determined.

It appears, therefore, to sum up, that although the lower rays are without any perceptible action on *Hydra*, by themselves or when mixed singly with the upper rays (as in purple), yet they partially counteract the attractiveness of the blue rays when mixed with them as they are in ordinary daylight, and of the green rays when mixed with them so as to form yellow (*i. e.*, white light minus blue). This paradoxical result I am at present unable to understand, but the problem is undoubtedly worthy of the most careful investigation.

Why the blue-green rays alone should be operative it is impossible to say. The recent works of Loeb and Groomé upon animal heliotropism, and the earlier work of Sachs, de Bary and others upon plants, show that in all probability the blue rays are the effective ones in all cases of heliotropic action, whatever its purpose or mode of origin, whether in plants or animals, whether

guided by differentiated visual organs or not. If this conclusion be well founded, the efficiency of the blue rays must depend upon some fundamental characteristic of protoplasmic action, and the sensibility to the lower rays, as manifested by differentiated visual end-organs in higher forms, has probably been secondarily acquired by an extension of the original blue-sensibility.

It seems hardly necessary to point out that this conclusion by no means implies that all forms of heliotropic action have the same physiological meaning. It relates solely to the *mode of stimulus*, not to the purpose of the actions called forth by the stimulus. Sneezing and winking may both be produced by a sudden visual stimulus, but we do not for this reason conclude that these actions must play the same physiological rôle.

To the ultra-violet rays the animals, as far as can be determined, are as indifferent as to the ultra-red.

V.—The last point to be considered relates to the mode in which the stimulus acts,—a question of greater importance than appears at first sight. There seems to be no doubt that blue rays impinging upon *Hydra* exert a directly attractive influence; for if an aquarium be supplied with blue light only (entering through a small window) the animals move pretty directly towards it, and do not simply wander aimlessly about until they reach the blue by accident. The case is different when a number of the animals, already situated on the illuminated side of a square aquarium, are offered the choice between a number of differently colored slips fastened to that side.

Under these conditions, as has been shown, the animals decrease under the red, yellow, and green glasses, and steadily accumulate under the blue, although no unmixed blue light impinges upon those individuals not actually behind the blue glass. The lower rays, however, exert no repellent action in themselves, and we must therefore assume that the animals tend to wander irregularly about until the blue areas are accidentally discovered. Observation shows, moreover, that the tendency to wander exists under every condition of illumination. By marking off the side of an aquarium into small squares it is easy to follow and accurately record the individual movements of a group of *Hydras* for

a long time. The results show that even after the animals have thoroughly established themselves in the usual position on the illuminated side they are to some extent continually on the march, and seldom remain in one spot more than a day or two, and the time is usually much less than this. I cannot make out that the movements are more active under the red, yellow, or green, or in darkness, than in daylight or under blue, though a *sudden change*, whether of color or of intensity, is apt to stimulate the movements for a time. This latter fact probably explains the comparatively rapid dispersal of the animals upon the substitution of a neutral color for blue (see tables), which at first sight seems to point to a direct repellent action.

On the whole, the facts seem to warrant the conclusion that *Hydra* has an innate (automatic?) tendency to wander, and that light and oxygen operate not so much by calling forth new movements as by the modification of indefinite movements that tend continually to recur irrespective of external stimuli. If this be so, the case shows an interesting analogy to the movements of plants, many of which (including heliotropism), as Darwin has so strikingly shown, have arisen through the modification by special stimuli of an innate circumnulatory movement. Some of these movements in plants, though no doubt unconscious, have an extraordinary likeness to purposive, intelligent acts. It would be difficult to say in what lies the superior claim of *Hydra* to recognition as a conscious, not to say intelligent, being.

Bryn Mawr, Pa., April, 1891.

REMARKS ON THE REPTILES GENERALLY
CALLED DINOSAURIA.

BY G. BAUR.

THE name Dinosauria was proposed by Prof. Richard Owen (1), in a paper on "British Fossil Reptiles," read before the ninth meeting of the British Association, at Birmingham in 1839. In this order were placed the genera *Megalosaurus*, *Hylaeosaurus*, and *Iguanodon*. Already in 1830, however, Hermann v. Meyer (2) had placed *Megalosaurus* and *Iguanodon* in a peculiar group of the fossil saurians, with "Extremitaeten wie bei den schweren Landsäugethieren." Kaup (3) follows H. v. Meyer, and calls the order containing *Iguanodon* and *Megalosaurus*: *Rieseneidechsen, Megalosaurier.*

Owen gave the following characters for the group he had called Dinosauria (*l. c.*, p. 102, 103):

DINOSAURIANS.

"This group, which includes at least three well-established genera of saurians, is characterized by a large sacrum composed of five ankylosed vertebræ of unusual construction, by the height and breadth and outward sculpturing of the neural arch of the dorsal vertebræ, by the two-fold articulation of the ribs to the vertebræ, viz., at the anterior part of the spine by a head and tubercle, and along the rest of the trunk by a tubercle attached to the transverse process only, by broad and sometimes complicated coracoids and long and slender clavicles, whereby crocodilian characters of the vertebral column are combined with a lacertilian type of the pectoral arch; the dental organs also exhibit the same transitional or annexent characters in a greater or less degree. The bones of the extremities are of large proportional size, for saurians; they are provided with large medullary cavities and with well-developed and unusual processes, and are terminated by metacarpal, metatarsal, and phalangeal bones, which, with the exception of the ungual phalanges, more or less resemble

those of the heavy pachydermal mammals, and attest, with the hollow, long bones, the terrestrial habits of the species. The combination of such characters, some as the sacral ones, altogether peculiar among reptiles, others borrowed, as it were, from groups now distinct from each other, and all manifested by creatures far surpassing in size the largest of existing reptiles, will, it is presumed, be deemed sufficient ground for establishing a distinct tribe or suborder of saurian reptiles, for which I would propose the name of *Dinosauria* " (p. 103).

A few years later, in 1843, Fitzinger (4) placed *Megalosaurus* in the family " *Megalosauri*," among the *Loricata*; *Iguandon* we find under the family name " *Therosauri*," among the order *Sauri*.

In 1845 H. v. Meyer (5) introduced the name *Pachypodes* for the group he had established in 1830, including *Iguanodon*, *Hylaeosaurus*, *Megalosaurus*, *Plateosaurus*.

Paul Gervais (6) established the families *Megalosauridae* and *Iguanodontidae* in 1853, without giving definition.

In 1866 Owen (7) characterized the *Dinosauria* thus :

" Cervical and anterior dorsal vertebræ with par- and diapophyses, articulating with bifurcated ribs; a few anterior vertebræ, more or less convex in front and cupped behind, the rest with flat or slightly concave articular ends; dorsal vertebræ with a neural platform; sacral vertebræ exceeding two in number; body supported on four strong ambulatory unguiculate limbs. Skin in some armed by bony scutes. Teeth confined to upper and lower jaws, implanted in sockets." He names the genera: *Iguanodon*, *Scelidosaurus*, *Megalosaurus*.

In the same year Haeckel (8) and Cope gave the first classification of the *Dinosauria*.

Haeckel considers the *Dinosauria* a subclass, which he divides in two orders :

" Erste Ordnung der *Dinosaurier* : *Harpagosauria* H.; Carnivore *Lindwürmer*. Zweite Ordnung der *Dinosaurier* : *Therosauria* H.; Herbivore *Lindwürmer*."

Haeckel uses the same name as Fitzinger for the herbivorous forms represented by *Iguanodon*.

The *Harpagosauria* are represented by *Megalosaurus*, *Hylaeosaurus*, *Telorosaurus*.

Cope's first note on the classification of the Dinosaurs was published in the *Proc. Acad. Nat. Sci., Phila.*, 1866, p. 317. He distinguishes *Orthopoda* with the genera *Scelidosaurus* Ow., *Hylaeosaurus* Mont., *Iguanodon* Mont., *Hadrosaurus* Leidy; and *Goniopoda* with the genera *Lælaps* Cope and *Megalosaurus* Buckl.

In 1870 Cope (9) characterized these in the following way :

ORTHOPODA.

"Cope, *Proc. Ac. Nat. Sci., Phila.*, 1866, 317. *Therosauria* Haeckel, 1866. Proximal tarsal bones distinct from each other and from the tibia, articulating with a tibia and with a terminal face of a well-developed fibula. The ilium with a massive, narrowed, anterior prolongation. *Hadrosauridæ*, *Iguanodontidæ*, *Scelidosauridæ*."

GONIOPODA COPE.

"*Proc. Ac. Nat. Sci., Phila.*, 1866, 317. *Harpagosauria* Haeckel, 1866. Proximal tarsal bones distinct from tibia; the latter closely embraced by the much-enlarged astragalus, on its inferior and anterior faces, forming an immovable articulation. Astragalus with an extensive anterior articular condyle below, above in contact with the fibula, which is much reduced, especially distally. Anterior part of the ilium dilated and plate-like. *Lælaps*, *Pœciliopleuron*, *Megalosaurus*, *Cœlosaurus*, and perhaps *Bathygnathus* and *Aublysodon*."

In the same paper a third group, *SYMPHYPODA*, is established, with the genera *Compsognathus* and *Ornithotarsus* and the following characters :

"First series of tarsal bones confluent with each other and with the tibia. Fibula distally much reduced. Anterior part of ilium dilated, plate-like."

Later it was found that *Ornithotarsus* belonged to the *Orthopoda*, *Compsognathus* to the *Goniopoda*.

Huxley (10) gave the first characteristic of the *Dinosauria* in 1869. "The bony exoskeleton is sometimes more highly

developed than in the Crocodilia, and sometimes absent. The centra of the posterior dorsal vertebræ are flat or slightly concave at each end, and they have crocodilian transverse processes and ribs. The centra of the anterior dorsal and of the cervical vertebræ are sometimes concave behind and convex in front (opisthocoelous). There are four or more vertebræ in the sacrum. The pelvis and bones of the hind limb are in many respects very like those of birds. No clavicles have been observed, and the fore limb is sometimes very small in proportion to the hind limb."

One year later Prof. Cope (11) gave the following characters: "Limbs ambulatory or prehensile. Ilium horizontal, supporting a long sacrum of five or six vertebræ, the anterior derived from the lumbar series. The acetabulum thrown forwards, and not complete, but perforate. Ischium long, longitudinal, posterior, supporting the parts, in front of a process. Ribs free, double-headed. Neural arches united by suture; chevron bones present."

The next paper is Prof. Huxley's (12) well-known memoir on the classification of the Dinosauria. The order Ornithoscelida is created, with two suborders:

"I. Dinosauria, with the cervical vertebræ relatively short, and the femur as long as or longer than the tibia.

II. The Compsognatha, with the cervical vertebræ relatively long, and the femur shorter than the tibia."

The Dinosaurs are now characterized fully:

"1. The dorsal vertebræ have amphicoelous or opisthocoelous centra. They are provided with capitular and tubercular transverse processes, the latter being much the longer.

2. The number of the vertebræ which enter into the sacrum does not fall below two, and may be as many as six.

3. The chevron bones are attached intervertebrally, and their rami are united at their vertebral ends by a bar of bone.

4. The anterior vertebral ribs have distant capitula and tubercula.

5. The skull is modeled upon the lacertilian, not on the crocodilian, type. There is a bony sclerotic ring.

6. The teeth are not ankylosed to the jaws, and may be lodged in distinct sockets. They appear to be present only in the premaxillæ, maxillæ, and dentary portions of the mandible.

7. The scapula is vertically elongated; the coronoid is short, and has a rounded and undivided margin. There is no clavicle.

8. The crest of the ilium is prolonged both in front of and behind the acetabulum, and the part which roofs over the latter cavity forms a wide arch, the inner wall of the acetabulum having been formed by membrane, as in birds.

9. The ischium and pubis are much elongated.

10. The femur has a strong inner trochanter; and there is a crest on the ventral face of the outer condyle, which passes between the tibia and the fibula, as in birds.

11. The tibia is shorter than the femur. The proximal end is produced anteriorly into a strong crest, which is bent outwardly, or towards the fibular side.

12. The astragalus is like that of a bird; and the digits of the pes are terminated by strong and curved ungual phalanges."

The Dinosaurs are divided by Huxley into three families:

I. Megalosauridæ; *Teratosaurus*, *Palæosaurus*, *Megalosaurus*, *Poikilopleuron*, *Lælaps*, and probably *Euskelosaurus*.

II. Scelidosauridæ; *Scelidosaurus*, *Thecodontosaurus*, *Hylæosaurus*, *Polacanthus* (?), *Acanthopholis*.

III. Iguanodontidæ; *Cetiosaurus*, *Iguanodon*, *Hypsilophodon*, *Hadrosaurus*, and probably *Stenopelyx*.

With 1877 begin the publications of Prof. O. C. Marsh, based on the extensive collections brought together by his collectors.

In 1877 a new order of reptiles is named *Stegosauria*, but no characters are given (13).

The year following the order *Sauropoda* of the *Dinosauria* is established (14), to contain the very large reptiles, named by Marsh *Atlantosaurus*, *Apatosaurus*, *Morosaurus*, and *Diplodocus*, and by Cope *Camarasaurus*, *Amphicoelias*, etc. The characters of this order are:

SAUROPODA.

"1. The fore and hind limbs are nearly equal in size.

2. The carpal and tarsal bones are distinct.

3. The feet are plantigrade, with five toes on each foot.
4. The precaudal vertebrae contain large cavities, apparently pneumatic.
5. The neural arches are united to the centra by suture.
6. The sacral vertebrae do not exceed four, and each supports its transverse process.
7. The chevrons have articular extremities.
8. The pubes unite in front by ventral symphysis.
9. The third trochanter is rudimentary or wanting.
10. The limb bones are without medullary cavities."

Cetiosaurus, a member of this group, had always been considered as one of the Crocodilia, and Owen (15) had placed it in a special group, *Opisthoccelia*.

In this Owen was followed by Haeckel, but not by Huxley, who placed Cetiosaurus among the Iguanodontidae. Seeley introduced the name *Cetiosauria* in 1874.

Another new order of reptiles was created by Marsh (16), under the name *Cœluria*, without characters, in 1881.

In the same year the first classification of the Dinosauria is given by Marsh (17).

The Dinosaurs are considered an order, and divided in five suborders: *Sauropoda*, *Stegosauria*, *Ornithopoda*, *Theropoda*, *Hallopoda*, *Cœluria*. The diagnoses are thus given:

Order DINOSAURIA Owen.

" 1. Suborder *Sauropoda* (lizard foot). Herbivorous. Feet plantigrade, ungulate; five digits in manus and pes. Pubes united in front by cartilage. No post pubis. Precaudal vertebrae hollow; limb bones solid. Family, *Atlantosauridæ*; genera, *Atlantosaurus*, *Apatosaurus*, *Brontosaurus*, *Diplodocus*, and *Morosaurus*.

2. Suborder *Stegosauria* (plated lizard). Herbivorous. Feet plantigrade, ungulate; five digits in manus and pes. Pubes free in front. Post pubis present. Vertebrae and limb bones solid. Family, *Stegosauridæ*; genus, *Stegosaurus*.

3. Suborder *Ornithopoda* (bird foot). Herbivorous. Feet digitigrade; four functional digits in manus and three in pes.

Pubes free in front. Postpubis present. Vertebræ solid; limb bones hollow. Family, *Camptonotidæ*; genera, *Camptonotus*, *Diracodon*, *Laosaurus*, and *Nanosaurus*.

4. Suborder Theropoda (beast foot). Carnivorous. Feet digitigrade; digits with prehensile claws. Pubes coössified in front. Postpubis present. Vertebræ more or less cavernous; limb bones hollow. Family, *Allosauridæ*; genera, *Allosaurus*, *Creosaurus*, and *Labrosaurus*.

5. Suborder Hallopoda (leaping foot). Carnivorous (?). Feet digitigrade, unguiculate; three digits in pes. Metatarsals much elongated; calcaneum much produced backward. Two vertebræ in sacrum. Limb bones hollow. Family, *Hallopodidæ*; genus, *Hallopus*.

DINOSAURIA (?)

6. Suborder Cœluria (hollow tail). Carnivorous (?). Family, *Cœluridæ*; genus, *Cœlurus*."

The year following, 1882, the Dinosauria are placed in a sub-class, with five orders (18).

1. Sauropoda. 2. Stegosauria. 3. Ornithopoda. 4. Theropoda.

a. Suborder Cœluria. b. Suborder Compsognatha. 5. Hallopoda.

The subclass Dinosauria is characterized in the following words: "Premaxillary bones separate; upper and lower temporal arches; rami of lower jaw united in front by cartilage only; no teeth on palate. Neural arches of vertebræ united to centra by suture; cervical vertebræ numerous; sacral vertebræ coössified. Cervical ribs united to the vertebræ by suture or ankylosis; thoracic ribs double-headed. Pelvic bones separate from each other, and from sacrum; ilium prolonged in front of acetabulum; acetabulum formed in part by pubis; ischia meet distally on median line. Fore and hind limbs present, the latter ambulatory and larger than those in front; head of femur at right angles to condyles; tibia with procnemial crest; fibula complete. First row of tarsals composed of astragalus and calcaneum only, which together form the upper portion of ankle joint."

After this Cope (19) established the following system, considering the Dinosaurs an order, with four suborders.

" Feet ungulate; pubis projecting and connected in front; no postpubis.	<i>Opisthocælia.</i>
Feet ungulate; pubes projecting free in front; postpubis present.	<i>Orthopoda.</i>
Feet unguiculate; pubes projecting downwards and coössified distally; calcaneum not produced.	<i>Goniopoda.</i>
Feet unguiculate; calcaneum much produced backwards; (?) pelvis.	<i>Hallopoda.</i>
In 1884 Marsh (20) again published another classification. He divided the sub-class Dinosauria into four orders and three sub-orders:	
1. Order Sauropoda.	
2. " Stegosauria.	
3. " Ornithopoda.	
4. " Theropoda.	
Suborder Cœluria.	
" Compsognatha.	
" Ceratosauria.	

The Hallopoda are now considered an order of reptiles, not placed within the Dinosaurs.

In 1885 Cope (21) placed the Crocodilia among the Dinosauria, and gave the following character: "Os quadratum immovably articulated, capitular and tubercular rib articulations distinct. Ischium and pubis distinct, the latter directed forwards, backwards, or downwards; two posterior cranial arches; limbs ambulatory; no procoracoid."

In 1887 (22) Baur divided the Dinosauria in three groups:

" A. Carnivorous Dinosaurs, *Harpagosauria* Haeckel, 1866.

I. *Goniopoda* Cope, 1886 (*Theropoda* Marsh, 1881).

B. Herbivorous Dinosaurs, *Therosauria* Haeckel, 1866.

II. *Orthopoda* Cope, 1866.

1. *Ornithopoda* Marsh, 1881.

2. *Stegosauria* Marsh, 1877.

C. Crocodilian-like Dinosaurs, *Sauropoda* Marsh, 1878.

III. *Opisthocælia* Owen, 1859."

In the same year Prof. Seeley (23) gave a new classification.

He reached the result "that the Dinosauria has no existence as a natural group of animals, but includes two distinct types of animal structure." These two orders are called Ornithischia and Saurischia.

ORNITHISCHIA.

"In this order the ventral border of the pubic bone is divided so that one limb is directed backward parallel to the ischium, as among birds, and the other limb is directed forward. Neither of these limbs of the pubis appears to form a median symphysis. The ilium is prolonged in front of the acetabulum as a more or less slender processor bar. The vertebrae are solid, and the skeleton is not pneumatic. The basicranial structure is distinctive differing from that of crocodiles and lizards. The body and limbs are frequently covered with scutes, which many form a complete shield or be reduced so as to be unrecognizable. The digits vary from three to five."

SAURISCHIA.

"In this order the pubis is directed forward from its symphysis with the ischium, and no posterior limb of the bone is developed. Both pubis and ischium appear to meet by a median symphysis, so that the arrangement and relation of the bones are lacertilian. The anterior prolongation of the ilium has a vertical expansion. The vertebrae are more or less pneumatic or cavernous, and in the dorsal region the neural arch is commonly elevated. The basicranial structure is sub-lacertilian. No armor has been found. The digits vary in number from three to five."

In 1889 Marsh (24) admits four orders of Dinosauria: Sauropoda, Stegosauria, Ornithopoda, Theropoda; Ceratosaurus, *Hallopodus*, and *Compsognathus* being placed among the Theropoda.

Cope (25) admits, partially at least, Seeley's classification, but he keeps the order Dinosauria, which he divides in two suborders: Saurischia and Orthopoda; the first with the inferior pelvic elements directed downwards, the second with the pelvic elements directed backwards.

Lydekker (26) divides the order Dinosauria in three suborders: Sauropoda, Theropoda, Ornithopoda. In the Ornithopoda he includes the Stegosauria of Marsh.

In 1889 he keeps this arrangement and divides the suborders in the following families (27):

- I. Ornithopoda.—Trachodontidæ, Iguanodontidæ, Scelidosauridæ, Stegosauridæ, Ceratopsidæ.
- II. Theropoda.—Anchisauridæ, Megalosauridæ, Compsognathidæ, Cœluridæ.
- III. Sauropoda.—Atlantosauridæ, Diplodocidae, Cetiosauridæ.

In 1890 Prof. Marsh (28) separated the Hallopoda from the Dinosauria with query, and placed them in a special order; at the same time he gave the family Ceratopsidæ, which he had established in December, 1888 (*Am. Journ. Sci.*), the rank of a suborder, with the name Ceratopsia.

After this Baur (29) expressed the opinion that Halopus is nearly related to Compsognathus, and that it is unnatural to place the Ceratopsidæ in a special suborder.

In the latest paper on the subject Prof. Marsh (30) has given up the suborder Ceratopsia, considering the Ceratopsidæ a family only.

Prof. Zittel (31) retains the order Dinosauria, which he divides in this way:

- I. Unterordnung Sauropoda. Families: 1. Cetiosauridæ. 2. Atlantosauridæ. 3. Morosauridæ. 4. Diplodocidæ.
- II. Unterordnung Theropoda. Families: 1. Zanclodontidæ. 2. Megalosauridæ. 3. Ceratosauridæ. 4. Anchisauridæ. 5. Cœluridæ. 6. Compsognathidæ. 7. Halopidae.

III. Unterordnung Orthopoda. A. Stegosauria. Families: 1. Scelidosauridæ. 2. Stegosauridæ. B. Ceratopsia. C. Ornithopoda. Families: 1. Camptosauridæ. 2. Iguanodontidæ. 3. Hadrosauridæ. 4. Nanosauridæ. 5. Ornithomimidæ.

After this review of the general classification of Dinosaurs we see that there are quite a number of different ideas. Leaving the older views aside, we have to-day the following principal opinions, taking the latest views of the different authors.

A. *The Dinosauria are a Natural Group.*—1. The Dinosauria form a subclass of reptiles, containing four orders: 1. Sauropoda. 2. Stegosauria. 3. Ornithopoda. 4. Theropoda (Marsh).

2. The Dinosauria form an order of reptiles, containing three suborders: Sauropoda, Ornithopoda, Theropoda (Lydekker); Sauropoda, Orthopoda, Theropoda (Zittel).

3. The Dinosauria form an order of reptiles, containing two suborders: Saurischia, Orthopoda (Cope).

B. *The Dinosauria are not a Natural Group.*—The reptiles generally called Dinosauria belong to two distinct orders: Ornithischia and Saurischia (Seeley).

The first question to decide is, Do the Dinosauria represent a natural group or not? To examine this we will proceed to study a member of each of the three groups, Sauropoda, Orthopoda, and Theropoda, and compare these members among themselves. Of the Orthopoda especially we will take as a type *Iguanodon*, the structure of which is best known through the different publications of Dollo in the *Bull. Musée Royal d'His. Nat. de Belgique*; of the Sauropoda we will take *Diplodocus*, described by Marsh; and of the Theropoda, *Ceratosaurus*, also made known by Marsh. We begin with the skull, then treat the vertebræ, the shoulder girdle, the pelvis, the fore and hind limbs, the abdominal ossicles, and the dermal ossification so far as necessary.

I. THE SKULL.

Iguanodon.—All that I have to say about *Iguanodon* is based on the careful descriptions of Dollo (32).

1. The brain-case is completely ossified; a very strong alisphenoid being present.

2. The premaxillaries are separate, and there is a strong process extending between the nasals and mandibles, excluding the maxillaries from the nasal opening.

3. No epipterygoid (columella).

4. The jugals are fixed to a special process of the maxillaries; they are not placed in the same level with the alveolar border, but a considerable distance outside of it. They do not reach the end of the dental series. They are in connection with the lachrymals, postfrontals, quadratojugals, and maxillaries. They bound the orbits inferiorly, and also somewhat posteriorly.

5. The quadratojugals are placed between quadrate and jugal, but do not touch the squamosal.
6. The squamosals do not send down a process to join the quadratojugal.
7. The quadrate is very elongate, with its lower end directed forwards; there is a well-developed pterygoid process.
8. The mandible has a distinct predentary line.
9. The dentary has a greatly developed coronoid process.
10. The external nasal openings are limited by the premaxillaries and nasals.
11. The prelachrymal fossæ are small, and limited by the maxillaries, prefrontals, and lachrymals.
12. The orbits are limited by the supraorbitals, lachrymals, jugals, and post-fronto-orbitals.

Diplodocus.—These notes on Diplodocus are based on the figures of Prof. Marsh, which, however, are not quite correct, as I found from the study of the original specimens.

1. The brain-case is completely ossified; a very strong ali-sphenoid being present.
2. The premaxillaries are separate, and there is no process extending between the nasals and maxillaries, excluding the maxillaries from the nasal opening.
3. No epipterygoid (columella).
4. The jugals are placed in the same level with the alveolar border of the maxillaries. They do not reach the end of the dental series. They are in connection with the lachrymals, post-orbitals, quadratojugals, and maxillaries. They bound the orbits only pre-inferiorly.
5. The quadratojugals are placed between the quadrate and maxillary, but do not touch the squamosal.
6. The squamosals do not send down a process to join the quadratojugals.
7. The quadrate is elongate with its lower end strongly directed forward. There is a very large pterygoid process.
8. The mandible has no predentary bone.
9. The dentary is without coronoid process.

10. The external nasal openings are limited by the premaxillaries, maxillaries, and nasals.

11. The prelachrymal fossæ are large, limited by the maxillaries, prefrontals, lachrymojugals. (The suture between jugals and lachrymals seems to be very indistinct.)

12. The orbits are limited by the post-fronto-orbitals, and lachrymojugals.

Ceratosaurus.—Mostly after Marsh. 1. The brain-case is not ossified in front; there are no strongly ossified alisphenoids; this region like *Sphenodon*.

2. The premaxillaries are separate; there is no process extending between the nasals and maxillaries, excluding the maxillaries from the nasal opening.

3. An epipterygoid (columella).

4. The jugals are placed in the same level with the alveolar border of the maxillaries, and reach the end of the dental series. They are in connection with the lachrymals, postorbitals, quadratojugals, and maxillary.

5. The quadratojugal is placed between quadrate and jugal, and seems to touch the squamosal.

6. The squamosal sends down a small process to join the quadratojugal.

7. The quadrate is very much like that of *Sphenodon*, with a foramen between quadratojugal and quadrate, and directed backwards with its distal end. There is a very large pterygoid process.

8. Mandible without predentary bone.

9. Dentary without coronoid process.

10. The external nasal openings are limited by the premaxillaries, nasals, and maxillaries.

11. The prelachrymal fossæ are large, limited by the prefrontals, lachrymals, jugals, and maxillaries.

12. The orbits are limited by the prefrontals, frontals, post-fronto-orbitals, jugals, and lachrymals.

By comparing these three forms it is evident that *Iguanodon* stands quite isolated. It shows the peculiar lower jaw, the peculiar

nasal openings from which the maxillaries are excluded,¹ and the peculiar maxillary with the free posterior dentary end.

From the study of the skulls alone it is evident that Iguanodon has to be separated entirely from Diplodocus and Ceratosaurus; that there is no affinity whatever among these animals, which could permit us to place them in a common group may it be called a subclass or an order of reptiles.

But I have to say exactly the same in regard to Diplodocus and Ceratosaurus. Diplodocus is of a crocodilian pattern, showing a well-developed alisphenoid; Ceratosaurus, however, is typically Rhynchocephalian or Proganosaurian in nearly every detail, and it is certainly very much more related to these groups than to any other group of the so-called Dinosauria. The study of the skull alone would be sufficient to show that the Dinosauria is an absolutely unnatural group without any right of existence; it shows that the three members, Iguanodon, Diplodocus, and Ceratosaurus belong to three distinct groups of Monocondylia, with very little relation to each other.

II. THE VERTEBRAE.

The vertebrae are of the character of the Archosauria, the dorsals having well-developed transverse processes. As is well known from the study of the Testudinata and Crocodilia, the character of the articular faces of the centra of the vertebrae is of very little value in tracing the phylogenetic relation of groups. The sacrum, however, shows peculiarities.

Iguanodon.—In Iguanodon the sacral ribs are placed more or less between the centra of the sacral vertebrae. They are united to distinct diapophyses of the neural arches and to the centrum; the diapophysis may extend in some forms (Agathaumas) as far as the end of the sacral rib, but it is never separated from it. In other words, in Iguanodon the ilium is separated by sacral ribs, which are placed between the centra and to which diapophyses of the neural arches are suturally united or coössified.

¹ This condition resembles very much that seen in mammals, in which we also have a process of the premaxillary extending between nasal and maxillary. In birds the maxillary is excluded from the nasal opening by the descending branches of the nasal. A somewhat intermediate condition is seen in *Aëtosaurus*.

Diplodocus.—In *Diplodocus* and its allies the sacral ribs are not intervertebral, but are connected with the centra of the vertebræ only, without diapophyses.

Ceratosaurus.—In *Ceratosaurus* and its allies the sacral ribs are intervertebral, but entirely free from the well-developed diapophyses, which also support the ilium. The diagrammatic figures show these relations. We see also that the structure of the sacrum shows greater differences than we find in a natural group, and also shows that the Dinosauria must be given up.

III. THE SHOULDER GIRDLE.

In the shoulder girdle we find, as in all Archosauria, a simple coracoid and an elongate scapula. So far no clavicles have been found, and I think that these elements are absent in *Iguanodon* and *Diplodocus* and the allied forms, but I should not be surprised at all if further discoveries would demonstrate the presence of clavicle and interclavicle in the megalosauroid forms.

IV. THE PELVIS.

Iguanodon.—The pubis of *Iguanodon* and its allies at once distinguishes it from all the other groups. As is well known and now shown without doubt, the ectopubis or pectineal process in this form is exceedingly developed; the entopubis or true pubis being directed backwards. This character alone is sufficient to separate *Iguanodon* far from *Diplodocus* and *Ceratosaurus*. In the highest specialized members of the *Iguanodon* group—*Agathaumas* (*Triceratops*), for instance—the ectopubis is enormously developed, the entopubis being quite rudimentary.

Diplodocus.—Here we have the pubis directed forwards, and pierced by the obturator foramen, all the bones of the pelvis being very massive.

Ceratosaurus.—Also in this form the pubes are directed forwards, but are closely united at the distal two-thirds, appearing like a chevron bone when seen from front; also the ischia are united at the distal end; the elements of the pelvis being slender.

It is evident that *Diplodocus* and *Ceratosaurus* resemble each other very much more in the structure of the pelvis than they do

in comparison with *Iguanodon*. The pelvis of these two forms can be reduced to the type seen in the Rhynchocephalia and Squamata.

V. THE FORE AND HIND LIMBS.

The structure of the limbs is of very great taxonomic value in a definite animal group of forms; but if we would take the limbs alone to establish a system we would be led to the most absurd results. The order Enaliosauria was established for the Ichthyosaurs, and Plesiosaurs which are provided with paddles. But this is only a parallelism in structure. The Plesiosaurs have no relations whatever to the Ichthyosauria. The same we may say in regard to the Dinosauria. The *Iguanodon*-like forms resemble very much the *Megalosaurus*-like forms; but there cannot be the slightest doubt that this resemblance does not mean affinity, but parallelism.

VI. ABDOMINAL OSSICLES.

So-called abdominal ribs were present in the megalosauroid forms, as shown by Deslongchamps. They have not been discovered yet in *Iguanodon* and *Diplodocus*, and it is impossible to determine with our present knowledge whether they were present or not.

VII. DERMAL OSSIFICATIONS.

Dermal ossifications are known in the *Iguanodon*-like forms, especially in the highly developed Stegosauridae and Agathau- midæ; they seem to be absent in the *Diplodocus* and *Ceratosaurus* forms. I do not consider such ossifications of great taxonomic value, especially not for ordinal characters.

If we now recapitulate, we have found that the structure of the skull and sacrum of *Iguanodon*, *Diplodocus*, *Ceratosaurus*, make it sure that these three animals are in no near relation to each other; that they doubtless are the representatives of three different groups; that the Dinosauria have to be given up. The question now comes up, What names shall we apply to the three groups of archosaurian reptiles represented by *Iguanodon*, *Diplodocus*, and *Ceratosaurus*?

Iguanodon belongs to the group which has been called Therosauri by Fitzinger, 1843; Therosauria by Haeckel, 1866; Orthopoda by Cope, 1866; Ornithopoda and Stegosauria by Marsh, 1881; Ornithischia by Seeley, 1887. Of all these names that of Therosauri or Therosauria has the priority. But I do not believe that this name will be favored. I think it best to introduce a new significant name for this group of archosaurian reptiles: *Iguanodontia*,—like Crocodilia, Plesiosauria, Ichthyosauria, Aëthosauria, etc., the most typical representative of this group being Iguanodon. To this group belong the families, *Iguanodontidæ*, *Hypsilophodontidæ*, *Hadrosauridæ*, *Ornithomimidæ* (?), *Scelidosauridæ*, *Stegosauridæ*, *Agathaumidæ*.²

Diplodocus belongs to the group which has been called Opisthocœlia by Owen, 1859; Cetiosauria by Seeley, 1874; Sauropoda by Marsh, 1878. I think it best to use the name *Cetiosauria* introduced by Seeley, *Cetiosaurus* being the oldest member of the group, and doubtless synonymous with one and probably more of the American genera. Of this group there is evidence so far of only one family, the *Cetiosauridæ*.

Ceratosaurus is a member of the group which has been called Megalosauri by Fitzinger, 1843; Harpagosauria by Haeckel, 1866; Goniopoda by Cope, 1866; Theropoda by Marsh, 1881; I propose to use the name *Megalosauria* for this group. It is the oldest name used, and *Megalosaurus* is the oldest genus known, and there is no doubt that one or more of the American generic names will prove to be synonyms of it.

In this group the following families can be distinguished: *Zanclodontidæ*, *Anchisauridæ*, *Megalosauridæ*, *Compsognathidæ*, *Cœluridæ*.³

As the result of this paper I may state this:

1. The group generally called Dinosauria is an unnatural one, which is composed of three special groups of archosaurian rep-

² *Ceratops* Marsh is the same as *Monoclonius* Cope, as I know from actual study of the types. That *Agathaumas* Cope is the same as *Triceratops* Marsh will be admitted by everybody who will compare the original plates of the sacrum, dorsal vertebræ, and the ilium of *Agathaumas*, by Cope, with those of *Triceratops*, given by Marsh.

³ I think that *Macellognathus* Marsh, which has nothing whatever to do with the Testudinata, belongs to this family and to *Cœlurus*.

tiles, without any close relation between each other. The Dinosauria do not exist.

2. The so-called Dinosauria contain three groups of reptiles, which ought to be called Iguanodontia, Megalosauria, and Cetiosauria.

The distinctive character of these three groups are :

IGUANODONTIA.

Brain-case completely ossified; a well-developed alisphenoid; no epipterygoid (columella); premaxillaries with a posterior outer process extending between nasals and maxillaries, excluding maxillaries from nasal openings; jugals fixed to a special process of the maxillary outside the alveolar border; posterior alveolar end of maxillaries free; not connected with jugals or quadratojugals; quadrate directed forward; mandible with a distinct predentary bone; dentary with greatly developed coronoid process; sacral vertebrae with ribs and diapophyses united, intervertebral; pubis consisting of two branches; the anterior one ectopubis (pectenial process, prepubis) greatly developed: the entopubis directed backwards, well developed or rudimentary; ilium very much extended in front and also behind.

CETIOSAURIA.

Brain-case completely ossified; a well-developed alisphenoid; no epipterygoid (columella); premaxillaries not excluding maxillaries from nasal opening; jugal and quadratojugal forming a continuation of the posterior border of the maxillary in the same plane; quadratojugal in connection with maxillary; quadrate directed forwards; mandible without predentary bone; dentary without coronoid process; sacral vertebrae with ribs only vertebral; pubis consisting of one branch, the entopubis only, directed forwards.

MEGALOSAURIA.

Brain-case not ossified in front; no ossified alisphenoid; an epterygoid (columella); premaxillaries not excluding maxillaries from nasal opening; jugal connected with alveolar end of maxillary, on the same plane; quadratojugal free from maxillary; quad-

rate directed backwards; mandible without predentary bone; dentary without coronoid process; sacral vertebrae with ribs intervertebral; and diapophyses without connections with ribs; pubes directed forwards, and strongly united at the ends.

The Iguanodontia appear in the Lias with all characters (*Scelidosaurus*), and form an absolutely isolated group so far. The nearest relations seems to be with birds rather than with any other groups of the Monocôndylia. Whether the peculiar condition of the premaxillaries and the relations of the jugal to the maxillary, which remind us of the arrangement in mammals and some Theromora, indicates affinity to the ancestral forms of these groups, I am unable to say; but the fact that in mammals the pubis is also turned back has to be noticed.

The Iguanodontia reach to the Upper Cretaceous, and show in *Agathaumas* and *Diclonius* their highest specialization.

The Cetiosauria are confined to the Jurassic, Wealden, and Cretaceous (Cambridge Greensand).⁴ They seem to have their nearest relatives in the Belodontidae. The Crocodilia, with their peculiar pelvic arch, seem to be also related to this group.

The Megalosauria extend from the Triassic to the Cretaceous. The skull is of the pattern of *Paleohatteria* of the Proganosauria and the Rhynchocephalia, and it seems very probable to-day that the Megalosauria have developed from the Rhynchocephalia. *Protorosaurus* seems to be in this line.

The earliest reptiles doubtless go back to the Carboniferous, from which formation we do not know a single reptile so far. This is made probable by the existence in the Permian and Lower Triassic of different groups of Reptilia. It is very likely that birds began to be branched off already in the Lower Triassic, probably from a group which gave also origin to the Iguanodontia; but to decide this question is not possible to-day. I still believe with Hitchcock that a great number of the tracks in the Connecticut Triassic sandstone are the tracks of true birds, not of any of the Megalosauria known to-day. All Megalosauria known have a long tail, and we ought

⁴ The metatarsals figured by Seeley of a Dinosaur from the Cretaceous Greensand cannot be distinguished from those of *Morosaurus*.

to expect to find impressions of a tail, with the impressions produced by the hind limbs, but this we do not. The impressions, therefore, seem to be produced by an animal having a short tail. Some characters of birds remind us of the Megalosauria; but the fact remains that we know hardly anything about the actual ancestors of this branch of the Monocondylia. The birds have a well-ossified alisphenoid, no epityygoid, and there seems to be little doubt that the avian ancestors of the birds of to-day had already this character; but the ancestors of these must have had the brain-case open in front, no ossified alisphenoids, but an epityygoid; and here, again, we reach a form like the Progano-sauria and Rhynchocephalia.

Clark University, Worcester, Mass., Feb. 11th, 1891.

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CUP-STONES NEAR OLD FORT RANSOM, N. D.

BY T. H. LEWIS.

APPARENTLY the earliest mention of cup-stones, in print, was in 1751, in a historical work on the Province of Brandenburg, by J. C. Bekmann. The author speaks of certain boulders there which have on them *näpfchensteine*, or little-bowl-stones, as he terms them. Next, in 1773, there was found at Lynsfort, in North Britain, a druidical altar full of "rock basons," which was pictured in Camden's *Britannia*, 1789. From that time on, at intervals, first incidentally, then by purposed search, interesting discoveries were made until, so far as the rings were concerned, almost every country on the earth was represented. As regards the cups, their distribution has not yet proved to be nearly so widespread. Still they have been found in the British Isles, France, Switzerland, Bohemia, Austria, Northern Germany, the Danish Islands, and Sweden; but these are all the European countries known to possess them, apparently, according to the authorities. Flitting now eastward over vast kingdoms we meet with them again in far-off India. Here, in 1867, Mr. Rivett-Carnac found cup-cuttings upon the stones of the cyclolites of Nagpoor, and, shortly after, upon rocks *in situ* of the mountains of Kumaon, where, in one place, he found them to the number of more than two hundred, arranged in groups of apparently parallel rows. In the Kumaon region he also found ring sculpturing, which very much resembled that which is seen in Europe. Outside of these named countries, and North America to be mentioned further on, the world is a blank as regards cup-cuttings on rocks, so far as our present knowledge goes, or at least to the extent that I have been able to find recorded information of the same.

Although met with and described nearly a century and a half ago, as hereinbefore related, it is only within the last forty-five years that incised cups on rocks and stones have been particularly

written about, either in Europe or in the United States, and speculative theories advanced concerning their origin and uses.

It was in 1847 that Messrs Squier and Davis, partners in original research in the state of Ohio, brought their operations to a close by the production of the "Ancient Monuments of the Mississippi Valley," the comprehensive work which methodically displayed all that was then known of the antiquities of the great region implied by that geographical expression. In this book (on page 206) there is a description, with wood-cut illustration, of a block of sandstone which had been found in some unnamed Ohio mound. The stone weighed between thirty and forty pounds, and showed several circular depressions, evidently artificial, which our authors thought were used as moulds for the purpose of hammering thin plates of copper into small bosses of concavo-convex shape, such as had been often found. This is the prototype of the cup-stones of the western hemisphere.¹

Professor Daniel Wilson, of Toronto, in his "Prehistoric Man," (third edition, 1876, Vol. I.), also devotes several pages to the subject, and gives drawings of two cup-stones found, too, in Ohio. Of the first he speaks thus: "A cupped sandstone block on the banks of the Ohio, a little below Cincinnati. Others much larger were described to me by Dr. Hill," etc. The second one he describes as a "cupped sandstone boulder," found near Tronton [Ironton] in 1874. The author, in this work, considers that the use of these cups—everywhere, all the world over—was to grind the ends of stone implements, and that where they were accompanied by concentric circles and other devices the latter were no more than additions of idle fancy.

The late Professor Charles Rau, of Washington, D. C., seems, however, to be the first writer in the United States to bring forward and collate comprehensively in a special treatise the data relating to cup-stones on this side of the Atlantic, and to treat of

¹ Were the facts concerning the *Teololinga* rock, situated sixteen leagues southeast of Orizaba, Mexico, exactly known, it might with propriety take precedence here in the text of the Squier and Davis stone; for it was discovered in 1805 by Captain Dupaix, who said that on its surface were some circular holes of little depth. By reason of the dissimilarity of the published representations of it, however, Professor Rau (1881) thought that a proper doubt remained, not to be removed until the stone had again been examined and reported upon.

their resemblance to those found in the eastern hemisphere. In his "Observations on Cup-Shaped and Other Lapidarian Sculptures in the Old World and America" (1881) he² describes a few specimens whose characteristics are undoubtedly. The best of these are the "incised rock" in Forsyth County, Georgia; the sand-stone block with cup-cavities discovered by Dr. H. H. Hill in Lawrence county, Ohio;³ and the sculptures on Bald Friar Rock in the usquehanna River, Cecil county, Maryland. Toward the end of the work Professor Rau gives the various speculations which have been published as to the purpose for which cup-and ring-cuttings were made, but states that after all that has been said concerning their significance in the Old World, he hardly ventures to offer an opinion of his own. Still he thinks that both kinds of sculpture belong to *one* primitive system, of which the former seems to be the earlier expression. Turning to America, he considers that here, as yet, the number of discovered cup-stones is by far too small to permit the merest attempt at generalization.

The author just referred to has shown in his book that true cup-stones have been found in the United States as far east as Connecticut and as far west as Illinois, but the fact that rocks having such incised work exist also far beyond the Mississippi valley has not yet, apparently, become known to the antiquarian world. It is therefore for the purpose of describing one so located that this paper is written.

The rock in question is situated in Ransom county, North Dakota, and, with others, it came under my observation in the middle of last August, at which time full notes were taken, and the pictographs to be described further on carefully copied.

Ransom county derives its name from a post of the United States army which was formerly maintained on the west side of the Shyenne River, in that part of its course known as the Great Bend. The top of the bluff on which the ruined fort stands is about two-hundred-and-fifty feet above the river. About one-quarter of a mile to the westward, on the north half of the south-

² In "Contributions to North American Ethnology," Vol. V., Washington, 1882.

³ This is the same as the "cupped sandstone boulder" already illustrated in Professor Wilson's "Prehistoric Man" (1876).

west quarter of section 11, town 135, range 58, there is a large spring known as the "Fort Springs," situated in the bottom of a deep ravine, which is about ninety feet below the fort site. It is probably formed by a seepage from "Big Slough," which starts about one mile south and extends some fifteen or twenty miles in a southerly direction. The bluff immediately to the west of the ravine rises to the height of about one-hundred-and-sixty feet, and on the top, over a quarter of a mile away in a northwesterly direction, there is a small knoll which was called "Bear's-Den Hill" by the Indians. On the steep slope of the bluff, about one hundred yards north of west from the spring and fifty-three feet above it, there is a large light-colored granite boulder, on which there are a number of incised lines, cups, and other figures. The base of the boulder, which is firmly imbedded in the side-hill, is eight-and-a-half feet in length and four-and-a-half feet in width, and on the side next to the spring extends out of the ground about three feet. The top surface on which the carvings occur is irregular in outline, and is seven feet two inches in length, and from two feet six inches to three feet ten inches in width, sloping slightly towards the east. The particular figures seen upon it, and reproduced here in fac-simile as regards their forms, are explainable somewhat as follows, viz.:

FIG. 1.—Apparently the horns of some animal.

FIG. 2.—A nondescript. There is a similar figure on the quartzite ledge near Little Cottonwood Falls, in Cottonwood county, Minn.

FIG. 3.—A crescent. This figure is often found along the Mississippi River in Minnesota, Wisconsin, and Iowa.

FIG. 4.—A nondescript animal.

FIG. 5.—A peculiar-shaped cross. There is one similar in form on the face of a cliff a few miles above Stillwater, Minn.

FIGS. 6, 6.—"Pins," so-called. There are two of the same shape on the quartzite ledge, among other figures, near the "Three Maidens," at Pipestone, Minn.

FIGS. 7, 7, 7.—Three pairs of cups, one set being joined by a straight groove, and the other two by curved grooves.⁴

⁴Sir James Simpson describes and figures an isolated stone near Balvaird, in Inverness-shire, Scotland, which has five pairs of cups that are joined by straight or curved grooves.

FIGS. 8, 8, 8, 8.—Are four long grooves with odd-shaped ends. These grooves are only about one-eighth of an inch in depth, while the ends are from one to one-and-a-half inches in depth.

CUPS (not numbered).—The cups or circular depressions are from about one-half-inch to nearly two inches in diameter, and one inch to one-quarter of an inch in depth. Some are perfect circles, while others are oblong in outline. There are thirty-four single cups and twenty-five cups that are connected with or intersected by grooves, making a total of fifty-nine positive cups, without considering the terminals of the four long grooves and others that are more doubtful. Where grooves intersect the cups an arbitrary line has been drawn on the illustration, in order to separate them and to more fully demonstrate the character of the designs. In every instance where this has been done the cups are well defined, but yet they cannot otherwise be fully shown on a tracing giving only surface outlines.

Within a radius of four hundred feet from the spring there are thirteen incised boulders of various sizes and shapes, the one here described being the largest and finest of the group. The pictures, etc., on five of the best ones were copied; the others having only slight grooves and a few cups were not.

On the bluffs on both sides of the ravine there are a number of ancient mounds of the mound-building period, one of which is located on the west side immediately above the spring.

There are other boulders at various places in the northwest on which these cup-like depressions occur, and they are also occasionally found on the face of perpendicular ledges and on the walls of caves, but in nearly every instance there are other incised figures on the same surface. It may be further stated that the cup-cavities as shown at the terminals of Fig. 5 of the illustration now given are also seen in connection with incised figures on rocks at these other localities referred to.

The cup-stones (large boulders or rocks) are not to be con-

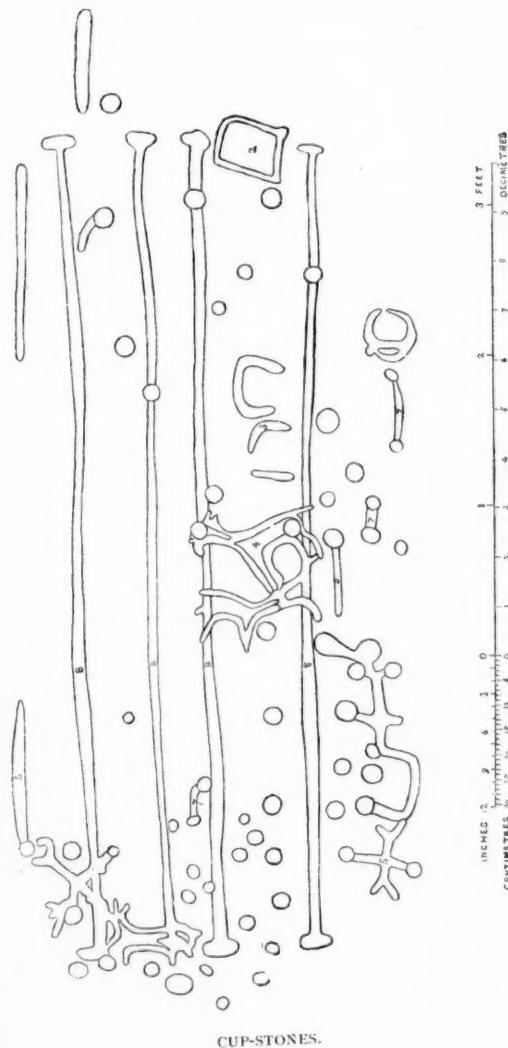
See Plate XIV., 2, of his "Archaic Sculpturings upon Stones in Scotland," etc., Edinburgh, 1867. The same type occurs on boulders and slabs found in France, Switzerland, and Sweden. Similar figures also appear on early British coins prior to Cunobeline's time (A.D. 40), and on the French-Keltic coins of moulded bronze. See Plates LIII. and LV. of Waring's "Stone Monuments," etc., London, 1870.

founded with the smaller stones called "nut-holders" or "anvils," which are from two to twenty inches in diameter, one to four inches in thickness, and which have one or more slight cavities or pits on each face. These cavities average about one inch in diameter, and very rarely exceed one-half inch in depth, the average being one-fourth of an inch. These relics are found throughout the west and south along the streams and lakes, and the prairies are no exception to the rule. Still less should cup-stones proper be confounded with the large circular excavations in rocks found in various regions which have been used as mortars. Mortars are found in fields. The rocks may be ten inches square and upwards, and the cavities range from six to fifteen inches in diameter and from one to five inches in depth. They are also found on the upper surface of ledges and on the tops of very large boulders. In one place in this vicinity there are at least twenty-five mortars on two acres of land.

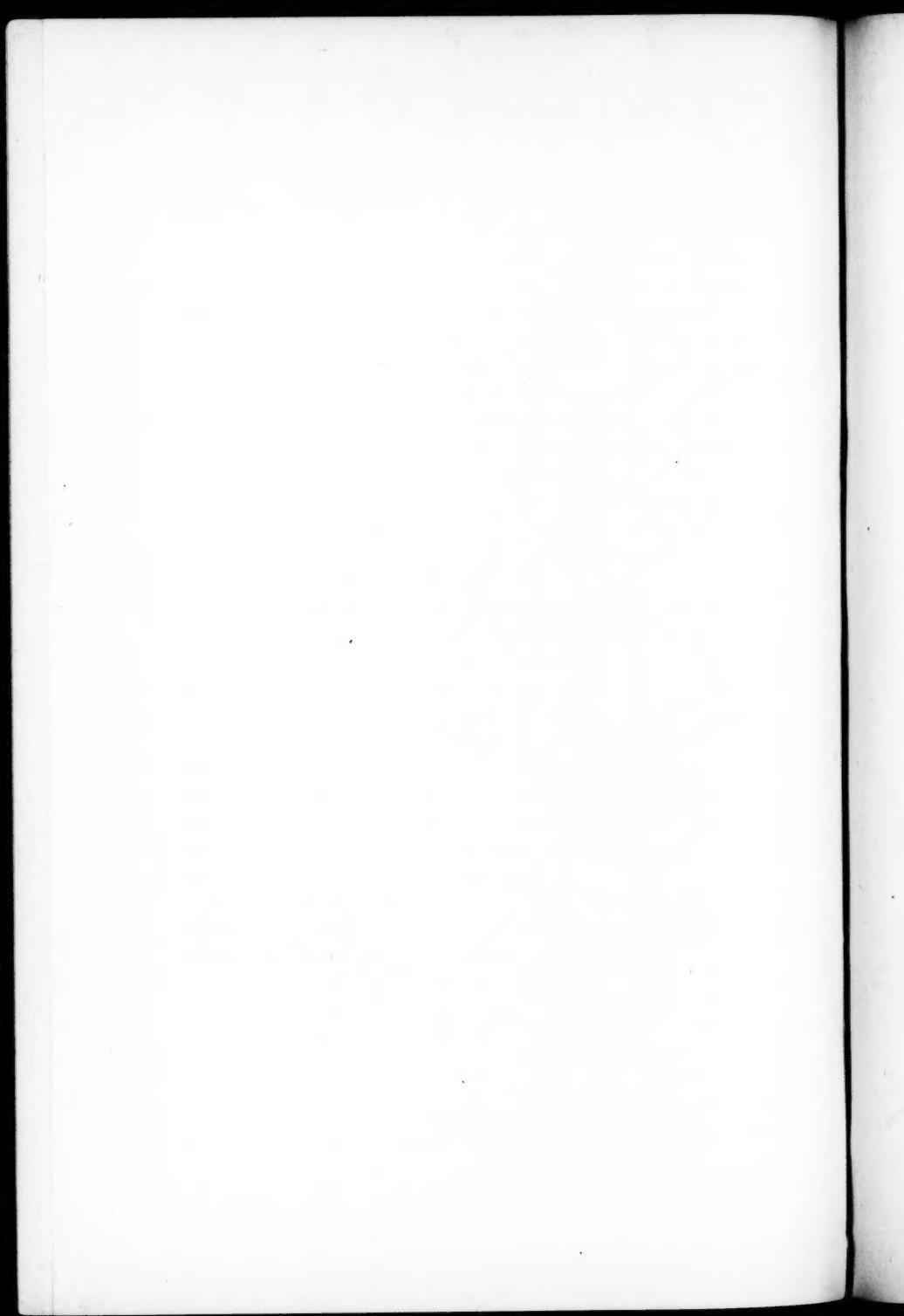
While the American cup-stones are similar in nearly every respect to those found in Europe and other portions of the globe, it would be the best policy to study them as an entirely separate class of antiquities, for in all probability there is not even a remote connection between the two hemispheres in this respect. After a thorough comparison has been made and the necessary links have been found, there will then be ample time in which to bring forward the facts to prove relationship. In the meanwhile, awaiting thorough exploration of the field, all such attempts, though interesting in a literary point of view, may be considered somewhat premature in a scientific one.

Since the above was written I have examined a book, just published, which treats of the same kind of ancient work. It appears nine or ten years after Rau's, and, so far as known to me, is the only general handling of the subject within that period. Its title is "Archaic Rock Inscriptions; an Account of the Cup and Ring Markings on the Sculptured Stones of the Old and New Worlds." It is of anonymous authorship, but bears the imprint of A. Reader, London, 1891, and is a 12mo of only 99 pages. The writer is evidently one of the mystical antiquarians who, to speak figuratively, have their eyes continually turned to those *ignes fatui* the

PLATE XI.



CUP-STONES.



elusive and ever unapproachable ancient faiths—the Tree, Serpent, Phallic, Fire, Sun, and Ancestor worships—and delight in the search for analogies concerning them. As regards the cup- and ring-markings, he himself adopts the phallic theory for their origin. His little book, however, admirably fulfills the promise of its title, for it not only includes most that prior writers collected, but gives interesting facts not accessible or not discovered when Professor Rau wrote. The most striking piece of new information is concerning the cup- and ring-markings on the rocks in the environs of Ilkley, Yorkshire,—a new locality. Here the cups have been counted into the hundreds in all; many of them are connected by grooves.

As regards America, all that this new author finds—and probably all there is to find—are two articles in the *AMERICAN NATURALIST*. The first one is contained in the number for December, 1884, and is entitled "Rock Inscriptions in Brazil," by J. C. Branner. The author does not use the word *cups* at all, nor do his diagrams show any; he only mentions in his text certain "points or indentations," often arranged in parallel vertical lines, and portrays them in the drawings, where also single circles are shown,—mostly provided with a central point. He found, however, "mortars" scooped out on the rocks by the river. The other article appears in the number for July, 1885, under the heading of "Ancient Rock Inscriptions on the Lake of the Woods," by A. C. Lawson. Neither does this writer mention *cups*, but his illustrations show concentric circles which have the usual central dot,

Tupelo, Mississippi, February 11th, 1891.

ON THE GROWTH-PERIODICITY OF THE POTATO-TUBER.¹

BY CONWAY MACMILLAN.

WHILE considerable research has been bestowed upon the physiology of bulbs, corms, and tubers, it does not appear that any extended observations have been made upon the method of growth of such an organ as the potato-tuber. It is a well-known fact that the growth in length of upright stems and other aerial organs is not regular, but exhibits a marked daily periodicity, the time of greatest average growth being in most cases not far from six o'clock in the morning. Upon this subject, since the researches of Sachs,² Baranetski,³ Pfeffer,⁴ and others, a number of observations have been made by various investigators. It appears that in most above-ground organs there is a clearly marked diurnal period, unless this period is obliterated by etiolation, suffocation, anæsthesia, or some other abnormal condition. We know, too, that besides the daily periodicity there is a grand-period of growth for each organ of the plant; that some organs reach the grand-period more rapidly or continue in it longer proportionately than other organs or similar organs on the other plant, or in the same plants under different conditions. The growth in length, then, of any organ is not regular, but is to be graphically represented as a wavy curve, with an ascending portion, a climactic portion, and a descending portion. In all of the parts of this large curve, the climax of which represents the grand-period of growth, one must notice the rhythmic pulsations due to the daily growth-periods, and more or less synchronous with the alternating periods of light and darkness, of higher and lower temperature, of less and of greater oxidation.

¹ Read before the Minnesota Academy of Science, May 5th, 1891.

² Arbeit. d. Würzb. Institute, 1873.

³ Die tägliche Periodicität d. Langenwachsthums, 1879.

⁴ Physiolog. Untersuchungen, 1873.

Seasonal rhythm in the growth in girth of organs is well known in the ordinary woody stems of Dicotyledons⁵ and Gymnosperms,⁶ where the increasing tensions of later months reduce the rate of growth below the rate of the earlier months. This periodicity is a more simple and readily explained form than those forms which have been alluded to above. It is found principally in organs provided with a cambium cylinder and a relatively inextensible bark, and is referred to merely by way of illustration. While the potato-tuber, which is to be considered, has a cambium area, it can scarcely be said to have a cortical area at all analogous to that of the erect tree-trunk. We shall not find the tuber, protected as it is and growing during a single season, affected by the conditions of alternate freezing and thawing, wind disturbance, stress, flexion, etc., which have so much to do with seasonal periodicity of growth in girth of woody stems.

A few months ago the writer was struck with what seemed to be a great dearth of investigations into the manner of growth of tubers, and forthwith gave some attention to devising a method by which the gap in our knowledge of tuber-physiology might be filled in part. After due deliberation a method was formulated and applied, with but imperfect success at first, but as experience became wider the imperfections were gradually remedied. In all of the experiments Mr. C. P. Lommen, student in biology at the University of Minnesota, gave much assistance in setting up apparatus, and by one or two helpful suggestions concerning certain technical difficulties which presented themselves in the course of our investigations. The method of research first adopted by us has been described elsewhere somewhat in detail,⁷ but upon this method certain important improvements have been made. The apparatus used was the Baranetski self-registering auxanometer, with electric clock attachment, manufactured by Albrecht, of Tübingen. At first both wheels of the apparatus were not employed, but afterwards it was found that two wheels could be combined in such a way as to multiply the tracings tenfold, and

⁵ Pfeffer. *Pflanzen-physiologie*, II., 89.

⁶ Hartig. *Anat. und Phys. der Holzpflanzen*, p. 366.

⁷ L. C. *Botan. Gazette*, May, 1891.

in our later experiments the wheel attached to the tuber-thread does not bear the tracing needle, but carries another thread on its large circumference, which runs to the small circumference of the tracing wheel. By this means hourly registrations are obtained instead of three-hour registrations as by the first method.

To recapitulate the method as finally developed: A potato-plant, grown in a box from which one end had been removed, was selected and carried to the experimenting room. With due care a tuber was exposed, and under it, resting upon the bottom of the box, a wooden block was placed in such a way that downward pressure would not disturb the position of the tuber. The root-stock umbilicus was protected from desiccation or injury during these processes of blocking up. Next a wooden jacket consisting of two squares of cigar-box material, held together by a number of slightly stretched rubber-bands, was fitted over the tuber in such a way that one square of the cigar-box wood clung to the block below and the other piece was parallel, but on the upper side of the tuber. To the center of this upper square a small screw was fixed, and to this screw a fine silver wire was tied,—since thread was rotted by the soil,—and this wire, after the whole apparatus of block, tuber, and jacket was covered with earth again, came to the surface of the soil under the first wheel of the auxanometer. An inch and a half above the ground a twisted linen thread, which gave better friction on the wheel, was attached to the silver wire, and this twisted thread was passed over the small circumference of the first wheel and drawn taut by a weight of about forty grams. Passing from the large circumference of the first wheel to the small circumference of the second was a linen thread equally weighted at each end, and over the large circumference of the second wheel was passed a thread, bearing at one end the tracing needle and at the other a small counterpoise. The tracing needle was placed in contact with the vertical smoked cylinder of the registering apparatus. This rested upon a clock-work in which a ratchet-wheel was caught by a lever attached to the clock-work by a spring and bearing at the opposite end an armature near the poles of a small electro-magnet. Connected with the magnet was a two-celled La Clanche

battery, but interpolated in the circuit was the electric clock, so adjusted that every hour the circuit was closed for a few seconds. During the closure of the circuit the electro-magnet attracted the armature, overcoming the tension of the spring and releasing one cog of the ratchet-wheel. By this means the vertical cylinder turned about one-sixteenth of an inch with the hands of the watch, and the tracing needle made a horizontal mark upon the smoked paper covering the cylinder. The opening of the circuit as the hands passed by the hour released the armature, allowed the spring to pull back the lever, and stopped the clock-work until the next hour, when a similar horizontal mark was made. During the hours, then, any expansion of the tuber would loosen the string attached to the jacket. Pulling against this the weights would turn the first wheel. This would turn the second wheel, and the indication of growth, one hundred times magnified, but in proper ratio, would appear as vertical tracings upon the smoked cylinder. This brief description of the Baranetski apparatus is given that the exact method of research may be apparent.

The first experiments upon the growing tuber, made in accordance with the method described in the *Botanical Gazette*, were satisfactory in so far that they demonstrated the availability of the Baranetski apparatus for the purpose for which it was employed. In one of the early experiments a trace of periodic growth was distinguished, but it did not seem to be sufficient to justify any confident assertion of periodicity. The first experiment continued two weeks. During this time the needle kept falling; at the close of the experiment it was about half an inch below its original level. In the second experiment certain drops in the tracings, usually in the early morning, were noticed, but I have since come to believe that not all of these were true growth-tracings, but were due, at least in part, to changes of temperature of the soil, the strings, and the atmosphere, with consequent shortenings, relaxations, and alterations in the needle-position. Against such accidental and confusing records there was a constant necessity of guarding. In general, a conservative statement of conclusions from these experiments with the single wheel is as follows:

1. The apparatus as set up indicated growth by cylinder-tracings.
2. A possible indication of periodicity in the growth may have manifested itself.

Further than this one could not go under the conditions of the experiment.

Desiring to obtain more perfect results, and to solve the question as to the manner of growth of the tuber, the improved method of setting up the apparatus was developed as described above, and the first experiment gave some interesting results. The method of culture in water employed by De Vries⁸ in the study of roots was contemplated, but rejected on account of certain practical difficulties.

The experiment began with a tuber about $\frac{3}{4}$ -inch in diameter. At this time the full-sized top of the plant had begun to perish from the effects of mildew. After attachment the registering needle gave two or three sharp drops, owing to the stretching of strings and general getting into equilibrium of the apparatus. After this stage was passed the needle began dropping very gradually. This slow descent was continued from eight o'clock in the evening until about eight o'clock in the morning. At this time the drop ceased, and horizontal tracings continued until about 1.30 P. M., when a short, abrupt hour's drop was registered, followed by a longer one, then by one shorter than the second but longer than the first, next by one longer than any, closely succeeded by another long one. After this the registrations were short, and the regular, gradual fall until 8 A. M. began. Here again the horizontal mark began and continued until 2 P. M., when a second drop began, on a somewhat smaller scale than the one registered the first day. The total extent of the second day's maximum, between 2 P. M. and 8 P. M., was about one-half of the first day's maximum. The third day the same tracings continued at the same hours,—only the tracings of the maximum were very much reduced, so as to be not more than one-quarter the total length of the second day's tracings. The fourth day's tracings were like those of the second day in almost every par-

⁸ *Landwirtschaftliches Jahrbuch*, 1880, Bd. IX., p. 37.

ticular, and those of the fifth day likewise, except that the latter showed a less maximum growth. The sixth day was peculiar. During this day no appreciable drop in the tracings was detected. The explanation of this cessation is not offered. It may be said, however, that the death of the top was now about complete, so far as the leaves and the secondary branches were concerned. Only in the lower part of the main stem was living green tissue to be found. During the whole twenty-four hours of the sixth day, then, no divergence of the tracings from the horizontal was observed; but during the succeeding twelve hours a slight drop began. At 7 o'clock A. M. of the seventh day a decided drop began, continuing until 11 A. M. There then succeeded a period of gradual dropping, which disappeared about 3 P. M. Another drop took place in the evening from 6 to 9 P. M. The eighth day began with a drop at 7 A. M., continuing until 11 A. M., when three hours of horizontal marks followed. At 2 P. M. a five-hour drop began, and continued as a gradual depression until 10 P. M. At 7 A. M. again another abrupt drop was registered, terminating at 11.30 A. M. At 3 P. M. a gradual, slight drop, lasting until 8 P. M., ensued. During four succeeding days the same rhythm continued, only the drops became slighter and slighter. Finally, on the fifteenth day the needle ceased to trace.

The explanation of these very curious maxima and minima in the growth of the tuber is a complicated matter. It can be given as yet only conjecturally. Before passing to any such conjectures it may be well to give in their order the conclusions arrived at from the line of research described above :

1. The increase in diameter of the potato-tuber is not regular, but is rhythmic.
2. Maxima of growth may occur either once or twice, and perhaps oftener, during twenty-four hours.
3. Maxima of growth are not of long duration, and are followed by periods of slower growth, or of entire cessation of growth.
4. The maxima of some days are greater absolute maxima than those of other days. This indicates a grand-period for the tuber.

5. Regular periodicity in the tuber continues after the periodicity of the aërial stem is suspended.

6. Connected with profound changes of condition in the aërial stem changes in the periodicity of the tuber may be noted.

7. There is some connection between the periodic growth of the tuber and the periodic growth of the aërial stem. What this connection is does not appear.

8. There is also, it is probable, an *independent* periodicity in the growth of the potato-tuber which is obscured and modified by the secondary *induced* periodicity, which is related to conditions of the aërial stem and its mode of growth.

Passing now to conjectural explanations of the observed periodic growth of the potato-tuber, it may be affirmed that very little can be expected at this stage of the investigations. Whether like embryonic shoots of *Hedera*, with their heliotropic irritability, the potato-tuber retains, somehow, in hereditary fashion, its above-ground periodicity, and thus gives hint of the time when its precursors were exposed to rhythmic alternation of light and darkness, is entirely an open question. On the other hand, it is equally uncertain whether the induced periodicity is due to one or many causes. Some lines of attack are indicated below, and it is hoped that they may be followed to their rational conclusion.

1. The rhythm of *assimilation* in the above-ground stem may affect the growth of the below-ground tuber. The synthesis of carbohydrates is a diurnal affair. From these carbohydrates the substance of the tuber is formed. Thus the rhythm above might induce a rhythm below.

2. The conversion of plastic into reserve materials is characteristic of an organ like the tuber. This conversion depends upon the activity of certain ferments which are results of destructive and constructive metabolic changes in the shoot area. These metabolic changes are consequent upon the *respiration* function, and this is a rhythmic function.

3. The *growth* of the above-ground stem is strongly periodic, and demands, in any plant, the same kind of material which would be supplied to a growing tuber. This drain upon the plastic material in one direction might induce a corresponding dearth of it in

another, so that the periodic growth of the above-ground stem might induce a periodic growth in the below-ground tuber.

4. The *asynchronous grand-periods* of growth of the different above-ground organs might be reflected in an irregular and erratic periodicity in the below-ground tuber.

5. *Combinations* of these various conditions, and a modification of them all by the independent rhythm of the tuber itself, would have to be considered, and only by the most elaborate and extended researches could the proximate causes for the observed tuber-periodicity be detected.

In closing this contribution to the physiology of tubers, one word may be added by way of note. It is possible, as may be shown, to apply auxanometer methods to root stocks by uncovering the root stock, attaching a silver thread, running it horizontally to the open side of the box, passing under a horizontal roller and upward, and finally adding the linen or silken thread which runs on the small circumference of the first wheel. Or, in this case, doubtless one wheel alone could be employed. Such study of underground stems, as in the grass root stock, the potato rhizome, or any other underground stem, would scarcely fail to throw some light upon the method of growth of the tuber. A comparison of underground organs should be made along this line.

University of Minnesota, Minneapolis, May 1st, 1891.

EDITORIAL.

EDITORS, E. D. COPE AND J. S. KINGSLEY.

IN these pages nearly four years ago (AMERICAN NATURALIST, XXI., p. 549) we made an appeal for some properly qualified person to write a "Complete Unnatural History." The necessary conditions of mind were stated at some length. There must be an instinctive ability to unerringly discriminate between the false and the true, and to invariably appropriate the former; a capacity to trace results from no adequate cause; and a firm conviction that all the so-called leaders of science were totally wrong, while the author is infallible.

Although we have not returned to the subject in the interval, the editors of the NATURALIST have been constantly on the lookout for the proper person. Numerous claims have been investigated, for many pretenders have arisen. It is useless to enumerate them all, for until this present year of grace, 1891, not a single candidate has been proposed who had the necessary grasp of subject, the proper disregard of cause and effect, and the all-important wealth of imagination. The Ohio minister who preached those celebrated sermons on the Creation in which petroleum was regarded as "strong-smelling grease," fried out from the decomposing bodies of antediluvian reptiles; the man who claimed that the Great Lakes are drained by an underground channel into the Mississippi River; the Buffalo doctor who maintained that bacteria are decomposing fibrin; the crowd of "pyramidologists,"—all were soon dismissed in short order. We debated longer in the case of a callow youth whom we found studying the relations existing between the abundance of birds and meteorological conditions,—not because of any capacity shown in choice of a subject, but from the methods of thought revealed by a glance at his notebook. A sample will suffice: "June 23d, 9 A. M. Saw two gulls. Sky clear. Wind S. W. June 23d, 9.23. Three loons on water, distant half mile. Sky clear. Wind S. S. W. June 23d, 9.37. Wilson's tern flying overhead towards west. Sky clear. Wind a little

stronger." And so on page after page. Imagination is here clearly lacking, and the promising youth was therefore turned over to the tender mercies of Dr. Chadbourne's Society for the Suppression of Useless Knowledge.

Now we believe that we have obtained the long-sought author. The essay which forms the basis of this opinion was published in January, 1890, in Vol. III. of *The Literary Light*, published by C. D. Raymer, 243 Fourth Avenue, S., Minneapolis, Minn. The essay is entitled "The Origin of Life and Species, And Theory by Which all Phases of Life, and Phenomena in Connection with Such, can be Readily Explained." Would we had the space to reproduce the whole essay! Excerpts must for the present answer, for doubtless this brochure will be embodied in the long-looked-for *Unnatural History*.

"An organism is a creature of environment, and has, like all things, obtained its life and all that belongs to it, and sequently all the possibilities of its future, during its incipiency by heredity. Whatever evolved properties and principles an environment may contain, generation rarely leaves any out. The future growth determines where and what from they were produced. Sequenty they are species."

"A reproduction, like all things, is composed of ponderables and imponderables. It is an organism with life attached, or composed of an aggregation of lives. . . . I have yet to learn that ponderables alone exhibit any activity whatever. They are invariably produced by, through, and are an organism."

"Generation is not a substance. It is a word to express the workings of the activities of a thing, a substance or a combination of substances by which phenomena are exhibited or produced. . . . It being the agent in all reproduction, performing the functions of the activities of a combination or an environment of material, containing definite substances, in first producing organized nuclei out of that material through the positive energies, usually in vast numbers. . . . They are called in the animal kingdom when fully developed, 'episoids' or 'zooids'; in the vegetable, 'pollen grains' or pollen."

"When we are first able to perceive nuclei with the most perfect lens yet constructed, we find them to be mere specks. By close observation we are able to perceive that the albuminoid substance is consumed, and that the nuclei grow, and in a short time are developed living organisms, just ready to emerge from the first stage of their existence."

"Bacilli by generation are a product of the properties of the products of the earth, where they first originate. Properties of the earth's products are a substance that we can usually taste."

"Intelligence is an imponderable substance, grown and produced by the animal kingdom, and as it and bacteria are products of products of the earth, they may be called kingdoms of growth. Human intelligence is a product produced by the animal man, the seat of which is located by phrenologists in his brain, in no less than thirty-five sections, and like all organisms in nature, may be classed into genera, species, and varieties."

"Should any error of fact or otherwise occur in my explanations, or should any phenomena in nature appear that no place can be found in my hypothesis, or a desire for further explanation on the subject, I would like to be informed of the fact, and what it is. If a fallacy, wherein does it lay.—GEORGE DAVIS; address, 2613 First Ave. S., Minneapolis, Minn."

We can assure a long-waiting world that if Mr. Davis attempts the *Unnatural History* the result will be a complete success.

—THE commission selected to examine and report on suitable locations for national reservations of land for the purpose of creating public parks has done a good work. They have selected about one hundred tracts from all parts of the country, which will be recommended to Congress for adoption. To the Yellowstone, the Yosemite, and the Sequoia Parks will be added one or more from nearly every state and territory of the Union. This is a measure which the scientific sentiment of the country will universally sustain. The preservation of tracts of forest, if only of limited extent, is highly important; and the preservation of game commends itself to everybody. Reasonable hunters are rare, and a good many men consider themselves sportsmen who

do not deserve the name. Without game reservations like the national parks, the large game of this continent will soon become extinct.

What we need further is an efficient forestry organization which shall prevent or suppress the forest fires which annually desolate our country. As our state organizations have shown themselves incompetent to deal with the question, the national government should take hold of it. It is to be hoped that the Forestry Commission of the Agricultural Department will be empowered to do so. Not only should the forest fires be suppressed, but their authors should be punished, whether the former are, as in some instances, at least, of incendiary origin or not. Railroad companies should be compelled to place spark catchers or extinguishers on their engines, under heavy penalties for non-compliance. Some action must be taken in the matter immediately, especially as we are now receiving the scum of Europe, whose carelessness of all matters of public economy is well known. We cannot afford to have our mountain regions converted into bare rocks, as most of the regions inhabited by the earlier civilizations of Europe now are. First the forests disappear, and then the soil from the mountain sides. Fire is a great friend of man, but in the hands of an unwatched European peasantry it is an evil great enough to render the punishment inflicted on Prometheus a wholesome warning to all who misuse this one of the greatest of nature's benefits.

RECENT BOOKS AND PAMPHLETS.

ABBOTT, C. C.—Annual Report of the Museum of Am. Archaeology of University of Penna., Vol. I., No. 1, 1890. From the author.

Anales de la Sociedad Española de Historia Natural.

Annual Report of the Cornell University Agri. Exp. Station, 1890.

Annual Report (Third) of the Marine Biological Laboratory, 1890.

Annual Report of the Curator of the Museum of Comparative Zoology at Harvard College for 1889-'90.

ALLEN, J. A.—Notes on Collections of Mammals made in Central and Southern Mexico, by Dr. Audley C. Buller, with Descriptions of New Species of the Genera *Vesperilio*, *Sciurus*, and *Lepus*.—List of Mammals collected by Mr. C. P. Streator in British Columbia, with Descriptions of two New Sub-species of *Sciurus*.—Notes on a Small Collection of West Indian Bats, with Descriptions of an Apparently New Species.—Description of a New Species and a New Sub-species of the Genus *Lepus*. Ext. Bull. Am. Mus. Nat. Hist., Vol. III. From the author.

AULD, R. C.—The Wild Cattle of Great Britain. From the author.

AYERS, HOWARD.—Concerning Vertebrate Cephalogenesis. Reprint from *Journ. Morph.*, Vol. IV., No. 2. From the author.

BODINGTON, ALICE.—Studies in Evolution and Biology. From the author.

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RECENT LITERATURE.

Wheeler's Report Upon the United States Survey West of the One-Hundredth Meridian.¹—An approximate notion of the extent of the work of the United States Survey west of the one-hundredth meridian, and of the labor involved in putting it upon record, may be had by a consideration of the extent of the territory involved.

The area within the United States west of the one-hundredth meridian of longitude (1,443,360 square miles) embraces, entire, the basins of the Colorado (270,000 square miles), Interior (208,600 square miles), Coast (100,900 square miles), and Sacramento (64,300 square miles); also that part of the Columbia (215,700 square miles) south of the forty-ninth parallel, and portions of the basins of the Missouri (338,200 square miles), Rio Grande (123,000 square miles), Arkansas (75,500 square miles), Brazos (34,800 square miles), and the Red River of the North (3,360 square miles).

Volume I., recently issued, closes the series. It is devoted to the geographical report, and is a most interesting as well as comprehensive description of the areas occupied, and their population, with their industries, their communications, irrigation systems, and artesian wells. The chapter on the Indians is the result of the author's personal observations, and contains advice worth heeding.

Appendix F contains a detailed account of the operations of the Wheeler survey. The first expedition took the field in May, 1871. The area embraced was 72,250 square miles, including portions of Central, Southern, and Southwestern Nevada, Eastern California, Southwestern Utah, Northwestern, Central, and Southern Arizona.

The survey of 1872 commenced on July 7th, and was completed on the 11th of December. The area embraced was 47,866 square miles, including portions of Central, Western, and Southwestern Utah, Eastern Nevada, and Northwestern Arizona.

In 1873 the expedition took the field in three divisions, organized respectively at Santa Fé, New Mexico; Salt Lake City, Utah; and Denver, Colorado. The area embraced was 72,500 square miles, including portions of Central and Southern Utah; Northern, Central,

¹ Report Upon the United States Geological Surveys West of the One-Hundredth Meridian, in Charge of Captain George M. Wheeler, Corps of Engineers, United States Army, under the Direction of the Chief of Engineers, United States Army. Volume I., Geographical Report.

Eastern, and Southeastern Arizona; Southwestern, Western, Northwestern, and Central New Mexico; and Central, Southern, and Southwestern Colorado. The area of the expedition of 1872 was entered along certain lines.

The several parties of the expedition in 1874 took the field from the camp of organization at Pueblo, Colorado, previous to and on the 6th of August. The territory embraced in the field of operations is bounded on the north by the latitude of the Spanish Peaks, and on the south by a latitude line passing through Santa Fé; on the east by longitude $104^{\circ} 07' 30''$ west, and on the west by the western boundary of Colorado and New Mexico, approximately.

The expedition of 1875 was organized in two sections of three parties each, one to operate from Los Angeles, California, and the other from Pueblo, Colorado, at initial points. The California division disbanded at Caliente, California, in November, 1875, and the Colorado section at West Las Animas, Colorado, November 25th. The area occupied was 39,169 square miles, including portions of Southern Colorado, Northwestern New Mexico, Southern California, small sections in Southwestern Nevada, and Western Arizona.

In 1876 the survey was again organized in two sections; the Colorado section, of two parties, at Fort Lyon, Colorado, and the California section, of four parties, at Carson City, Nevada. These sections took the field during the month of August, and were disbanded late in November at the above-named points. The areas that had been visited in 1871, '72, '73, '74, and '75 were again entered along certain lines when necessary to perfect the continuous belts of triangulation required to cover entirely the country under examination.

The expedition in 1877 was organized in three divisions; one, of two parties, at Fort Lyon, Colorado; a section, of two parties, at Carson, Nevada; and a third, of two parties, at Ogden, Utah. The field of survey comprised 32,477 square miles, in West Central Colorado, Central New Mexico, Northwestern Utah, Southeastern Idaho, Northeastern and East Central California, and South Central Oregon.

The areas embraced by the expeditions of 1873, 1874, 1875, and 1876 were again entered along certain lines when required to complete triangular observation.

The expedition of 1878 took the field in three divisions of three parties each. Of the Colorado division one party was organized at Fort Stanton, New Mexico, and two at Fort Garland, Colorado. The two parties of the California division were organized respectively at

Carson, Nevada, and at Camp Bidwell, California. Ogden, Utah, was the initial point of the Utah section. An area aggregating 25,550 square miles was occupied, situated chiefly in Southwestern New Mexico, Northern Utah, Northern, Central, and Southwestern California, Western Nevada, and Central Oregon.

Areas embraced during the seasons of 1873, 1874, 1875, 1876, and 1877 were again visited along certain lines when rendered necessary in perfecting triangulation and topographic details.

In 1879 several small parties were sent out to complete details in certain areas entered during the years 1873, 1875, 1877, and 1878.

The survey was terminated at the same time as that under Dr. F. V. Hayden, by the act of Congress creating the United States Geological Survey. While it was probably well that the geological survey should have been undertaken by a bureau of the Interior Department, it is not so clear that the topographical work should have been so disposed of. That this should be done by the United States Engineers seems eminently proper, since the educated men and the plant in instruments, etc., have been in that department of the government service from its commencement. To duplicate this seems to be an unwise and unnecessary expense.

The Itinerary of the Colorado Grand Cañon and River trip of 1871 is of absorbing interest.

The text is abundantly illustrated with fine chromo-lithographs, and the value of the work enhanced by the reproduction of old maps, with notes and references to geographical coördinates for a permanent official topographic atlas of the United States.

The value of a reliable geographical report on the territory discussed in this book is inestimable, and the highest praise is due to the distinguished author for the faithful, accurate, and above all, systematic production of so great an amount of geographic, geologic, and other scientific material.

General Notes.

GEOLOGY AND PALEONTOLOGY.

On the Non-Actinopterygian Teleostomi.—Material is not at present accessible in the United States from which to learn the structure of the median fins in the Holoptychiidæ and Osteolepididæ. In drawing up my Synopsis of the Families of the Vertebrata, in 1889,¹ I assumed that these fins had the primitive structure, such as is found in the oldest members of the Teleostomi (Tarassiidæ), Dipnoidæ, and other subclasses, viz., that the axonots are equal in number to, and continuous with, the neural spines of the Vertebrata. This definition threw the families in question into the Crossopterygia as distinguished from the Rhipidopterygia. In the latter the axonots are much reduced in number, so that one or two fused into a single piece supports each dorsal and anal fin.

Prof. Traquair has, however, stated that the dorsal fins of the Osteolepididæ are of the Rhipidopterygian type, and Mr. A. Smith Woodward in the Volume II. of the Catalogue of Fossil Fishes in the British Museum² confirms this statement, and shows that the Holoptychiidæ agree with them in this respect. He does not adopt the super-order Rhipidopterygia, but combines it with the Crossopterygia; and he places the families mentioned, together with the Rhizodontidæ, which is my Tristichopteridæ, in the order to which I referred the latter, the Rhipidistia. As regards this ordinal reference, it is clearly necessary on the evidence brought forward by Traquair and by Woodward. I do not, however, see that the Rhipidopterygia can be properly combined with the Crossopterygia, since the structure of the median fins is radically different, and one which offers as good ground for super-ordinal distinction as do the paired fins offer ground for the separation of the Actinopterygia. The Tarassiidæ and the Polypteridae possess the characters of the median fins which I viewed as characteristic of the Crossopterygia, while the paired fins, so far as can be discovered from the descriptions of the former,³ indicate two distinct orders within it.

¹ AMERICAN NATURALIST, p. 856.

² L. c., 1891, p. 321.

³ Smith Woodward, L. c., II., p. 317.

With this new information in our possession, it appears to me that the relations of these fishes is best expressed in the following way:

Subclass IV.—TELEOSTOMI.

There are four superorders of the Teleostomi or true fishes, which differ in the structure of the fins.

I. Median fins each with a single bone representing axonosts.

Paired fins unibasal ; *Rhipidopterygia.*

II. Median fins with numerous axonosts.

Paired fins with baseosts; pectorals with separate axonosts; ? uni- or pluribasal; *Crossopterygia.*

Paired fins with baseosts; pectoral fins with axonosts and baseosts confounded; pluribasal; *Podopterygia.*

Pectoral fins only with baseosts, these confounded ? with an axonost, and pluribasal; *Actinopterygia.*

Rhipidopterygia.

The orders of Rhipidopterygia are the following. They all have actinotrichia in place of fin-rays:

I. Paired fins with the basilars arranged on each side of the median axis, or archipterygial.

Median fins with basilars; *Taxistia.*

II. Paired fins with the basilars arranged fan-shaped at the end of short axis.

Median fins with basilars; *Rhipidistia.*
Median fins without, caudal fins with, basilars; *Actinistia.*

The Taxistia includes but one family, the Holoptychiidae, which is of Devonic age. The Rhipidistia includes the Tristichopteridae, from the Devonic and Carbonic; the Osteolepidae, from the same; and possibly the Onychodontidae, which are Devonic.

The Actinistia includes the single family of the Cœlacanthidae, which appears in the Lower Carbonic and ranges to the Upper Cretacic in both Europe and America.

The Crossopterygia includes two orders, as follows:

Dorsal baseosts and axonosts well developed; actinotrichia;

no fin-rays; pectorals ? unibasal; *Haplistia.*

Dorsal baseosts rudimental; fin-rays; pectorals tribasal; *Cladistia.*

But one family is included in the Haplistia, the Tarassiidæ, from the Lower Carbonic of Scotland. The Cladistia are represented by a family which is not known in the fossil state, Polypteridae, of the

rivers of Africa. The vertebræ in this genus are ossified and biconcave.

The *Podopterygia* has also two orders. They are thus defined:

Branchiostegal rays present;

Lysopteri.

No branchiostegal rays;

Chondrostei.

In these orders the notochord is persistent, and there are either actinotrichia, or fin-rays which are more numerous than the baseosts. Tail heterocercal or diphycercal.

The location of the *Lysopteri* in the *Podopterygia* by Woodward is due to the discovery by Traquair of the characters of the pectoral and ventral fins. The order includes four families, which differ as follows:

I. Tail heterocercal.

Teeth acute, external;

Palaeoniscidae.

Teeth obtuse, on palate and splenial;

Platysomidae.

No teeth;

Chondrosteidae.

II. Tail diphycercal.

Teeth present; scuta on body;

Belonorynchidae.

The *Chondrostei* include two families, the *Accipenseridae* and the *Polyodontidae*, both of which make their first appearance in the Eocene.—E. D. COPE.

Paleontology of Argentina.—A new journal devoted to natural history has just been established by M. Florentino Ameghino, at Buenos Ayres, under the title, *Revista Argentina de Historia Natural*. In the *Bulletin Bibliographic* is given the titles of the memoirs in the first number. Among the notes will be found the following statements of especial interest to paleontologists:

Two scientific expeditions are now at work in Southern Patagonia. One, under the direction of M. Ramon Lista, governor of the territory of Santa Cruz, which has for its object the geography of the country, left the Island of Pavon November 5th, 1890, in order to explore the lakes of the Andes. The other exploration, which is exclusively geological, under the direction of M. Carlos Ameghino, had for its object the study of geology, and to collect fossil remains in that region. The notes received up to this time (February, 1891) warrant us in stating that the results of this expedition surpass all preceding ones.

Farther north, the oligocene formations in the vicinity of Paraná were explored, during the year 1890, by MM. Scalabrini and Léon Lelong, who collected an immense quantity of bones of fossil vertebrates belonging to a type entirely unknown up to this time. A second formation of the same epoch, equally rich in fossil remains, has been discovered at Arroyo del Espinillo, about fifteen miles from the city of Paraná. Many of the species are new to science.

Finally, the Miocene sands which form the valleys between the spurs of the Acouquija (Tucuman and Catamarca) have furnished M. Manuel B. Zavaleta with remains of fossil mammals indicating a fauna almost entirely new, and which is badly represented in the formations of the same epoch hitherto explored.

These fossils will be described in the next number of the *Revista Argentina*, as well as the new type of Ungulates named by M. Ameghino *Notohippus toxodontoides*.—*Revue Scientifique*.

Water-Marks on Paleozoic Rocks.—In the *Quar. Jour. Geol. Soc.*, Nov., 1890, Sir Wm. Dawson has figured and described some peculiar markings of Paleozoic rocks. Bilobites, which have been regarded by Saporta, Delgado, and others as true algae, are, so far as American examples are concerned, undoubtedly the tracks of a marine animal, probably crustacean. Scolithus, originally placed with fucoids, represents burrows of worms with castings at their entrances. Sabellarites is a name the author proposes for certain elongated tubes composed of grains of sand and calcareous organic fragments associated with carbonaceous flocculent matter, indicating a horny sheath. They are formed of the phosphatic dejections of animals subsisting on Lingulae, Trilobites, Hyolithes, and other creatures having coverings of calcium-phosphate. Certain trunk-like forms in the Potsdam Sandstone are now shown to be concretions, the nucleus of which must have been a Chorda-like alga.

In many cases species of fossil plants have founded on rill-marks, notably the genera *Dendrophycus*, *Delessertites*, and *Vexillum*.

The Mutual Relations of Land-Elevation and Ice-Accumulation during the Quaternary Period are described by Professor Joseph LeConte as follows:

“It is generally agreed that the Quaternary was characterized by remarkable oscillations of land level, and corresponding oscillations of climate and of ice-accumulation. But the most opposite views are held regarding the time-relations of these two sets of phenomena. Some hold that the land-elevation was coincident with the cold and the ice-accumulation, and was at least one of its causes; and that the moderation of temperature and removal of the ice was coincident with the depression, and was its effect. Others take exactly the opposite view. I believe that the two extreme views may be reconciled, and all facts satisfactorily explained, by supposing (1) that the continental elevation which commenced in the Pliocene culminated in the early

Plistocene, and was at least one of the causes of the cold, and therefore of the ice-accumulation; (2) that the increasing load of ice was the main cause of subsidence below the present level; (3) that the removal of the ice-load by melting was the cause of the re-elevation to the present condition; but (4) that all these effects lagged far behind their causes." (Bull. Geol. Soc. Am., Vol. II., pp. 223-330.)

Submarine Channels of the Pacific Coast.—In a recent paper in the Bull. Geol. Soc. Am., Prof. Joseph LeConte discusses the submarine channels off the Pacific coast. The researches of Professor Davidson have brought to light twenty or more submarine channels on the coast from Cape Mendocino to San Diego. The distinctive feature of these, as contrasted with those on the eastern shore, is that they have no obvious relation to existing rivers. They are not a submarine continuation of any system of river valleys on the adjacent land. On the contrary, they run in close to shore, and abut against a bold coast, with mountains rising in some cases 3,000 feet within three to five miles of the shore-line, and wholly unbroken by any large river valleys. Mr. LeConte thinks it is impossible to account for this except by orogenic changes which diverted the lower courses, and places of emptying of the rivers, since the channels were made. He dates these changes about the end of the Pliocene or beginning of the Plistocene; they were probably coincident with the lava-flows and consequent displacement of the rivers, which took place at that time in the Sierra region.

Geological News.—Walter Harvey Weed has been working up the geology of the Cinnabar and Bozeman coal fields of Montana. He believes that facts warrant him in stating that these Coal Measures are of Laramie age. They are conformably overlain by volcanic material containing an abundant fossil flora of recognized Laramie types, in turn overlain by beds of fresh-water clays and sandstones of undetermined age, but which belong to what has heretofore been considered as undoubtedly Laramie strata. (Bull. Geol. Soc. Am., Vol. II., pp. 349-364.)—According to E. T. Newton, the rodents now known to occur in the brick-earth of the Thames valley are: *Castor fiber* Linn., *Spermophilus erythrogenoides* Falc., *Microtus (Arvicola) amphibius*, Linn., *Microtus (Arvicola) raticeps* Key. and Bl., *Myodes torquatus* Desm., and *M. lemmus* Linn. (Geol. Mag., Vol. VII., Dec., 1890.)—According to Mr. Robert Bell, ore bodies of the nickel and copper deposits in the Sudbury (Canada) district do not appear to have been accumulated like ordinary metalliferous veins from mineral

matter in aqueous solution, but to have resulted from igneous fusion. The fact that they are always associated with diorite, which has been left in its present positions in a molten state, points in this direction. (Bull. Geol. Soc. Am., Vol. II., pp. 125-140.)—According to R. Etheridge, Jr., there have been no geologic traces of man discovered in Australia up to the present time. The meagre details in the finds recorded render their evidence untrustworthy. (Proc. Linnean Soc. New South Wales, Vol. V., pp. 259-268.)—Professor von Ettingshausen, the eminent Austrian paleobotanist, has published a memoir on the fossil plants of New Zealand. This work is now being reproduced in English, and will be published with a large amount of additional information upon the same subject. (Rept. Col. Mus. and Geol. Surv. New Zealand, No. 20.)—The annual appropriation for the Geological Survey of Texas, made by the Legislature just adjourned, is \$35,000, exclusive of printing. Appropriations were also made for testing the lignites, for the publication of an accurate map of the state, and for the erection of a laboratory building at the University of Texas, which will contain a suite of rooms for the chemical department of the survey.

BOTANY.

North American Diatoms.¹—Seven years ago the botanists of this country were presented by Mr. Wolle with a handy book on Desmids, and three years later they found themselves again indebted to the industrious author for an equally useful work on the fresh-water Algae of the United States, exclusive of the Desmids (treated in the previous work) and the Diatomaceæ. We have now the pleasure of noticing a volume on the Diatoms of North America, in which the author completes his series of works on the Alge.

The plan of the work resembles that of Schmidt's "Atlas der Diatomaceen Kunde," in which figures serve in place of specific descriptions. Any one who has worked with these tiny plants knows full well that a good figure is of much more use in the determination of species than a great deal of descriptive text. The text is useful,

¹ Diatomaceæ of North America. Illustrated with twenty-three hundred figures from the author's drawings on one hundred and twelve plates. By the Rev. Francis Wolle, author of "Desmids of the United States," "Fresh-Water Algae of the United States." Bethlehem, Pa., The Comenius Press, 1890.

but the figures are much more so. Accordingly, our author has given us an abundance of figures, to represent our fourteen hundred species. He has also greatly simplified the work of comparison by having all the figures drawn to the same scale. By a little patience and practice the student of Diatoms may easily identify any species he may happen to find.

The book contains in addition to the plates a short preface, in which a brief historical account is given of the study of Diatomaceæ in this country; following this is a bibliography, including forty-seven citations; next follows a short "Introduction" of five pages, devoted to a summary account of habits, structure, etc.; after which comes Prof. H. L. Smith's "Conspiclus of the Families and Genera," as published in *The Lens*, in 1872. Last of all in the text is an alphabetical arrangement of genera and the American species under them (also arranged alphabetically), with references to the plates in which they are illustrated.

The work will at once become a necessity to every botanist who gives any attention to these interesting plants. The low price of the book (66.00) is another feature which will commend it to all.—CHARLES E. BESSEY.

The "Field Edition" of Gray's Manual.—This new book weighs fourteen ounces, and measures seven and three-eighths by four and five-eighths inches, and is but seven-eighths of an inch in thickness. The old book weighs more than two pounds, is an inch longer and wider, is twice as thick, and more than two-and-a-half times the bulk of the new one. With exactly the same type, and actually four more printed pages, the little book is admirably suited to the botanist's needs. Its leather cover and strong binding give it much greater durability than the old one, while its small size enables the collector to slip it easily into his pocket. Now that such an edition has appeared, we wonder that publishers did not venture to bring it out sooner.—A. F. Woods.

The Flora of the High Nebraska Plains.—The 20th of August, 1890, I set out for Western Nebraska, where I spent a month in collecting on the plains above 4,000 feet altitude above sea-level. Waiting for the train at Julesburg, Col., I could not withstand the temptation to take a walk on the bottomland of Lodge Pole Creek. The flora was far from rich. The grass here, as well as nearly everywhere in Deuel, Banner, and Cheyenne counties, Neb., was very short, and, on account of the long drought, dried up. The whole valley reminded me of a pasture in the month of November. A list of a few

of the plants I saw I give from memory: *Cnicus ochrocentrus*, *Liatris punctata*, *Cleome integrifolia*, *Cleomella angustifolia*, *Gaura parviflora*, *G. coccinea*, *Lygodesmia juncea*, *Eriogonum annuum*, *Psoralea tenuiflora*.

I spent about two weeks on the high table-lands of Deuel county, seven to ten miles northeast of Chappel. Here the principal grasses are the buffalo grass (*Buchloë dactyloides*) and the grama (*Bouteloua oligostachya*). Both, even when dry, make an excellent pasturage for cattle. The animals graze on them throughout the winter, if the snow is not too deep.

At first I strolled over the prairies and hills, but found very little of interest in the way of plants. Everything was dried up. Three kinds of cactus, viz., *Mammillaria vivipara*, *Opuntia missouriensis*, and *O. fragilis*; two thistles, *Cnicus undulatus* and *C. ochrocentrus*, *Yucca angustifolia*, *Erysimum asperum*, and *Astragalus sericoleucus*, were the most remarkable.

My trip had been a failure had I not found another field for botanizing, viz., the "sand-draws." Sand-draw is a word that I have not seen in any book, and still it is a word in common use among the settlers of Western Nebraska. The sand-draw is about the same as the "wady" of Arabia. It is a stream in which the water, as a rule, is never seen. The sand-draw looks like a dried-up stream with sandy or gravelly bottom. The sand is five to ten, or even up to fifteen or twenty feet deep. In this sand the water is running, perhaps the year round. In one of the smaller I saw a well dug, about fifteen feet deep, that contained water in the month of August.

In the sand-draws I found many plants which for their beauty are well worthy of cultivation. Among others I may mention the pink-purple *Ipomoea leptophylla* (also remarkable for its immense root, weighing sometimes as much as 100 pounds); the white prickly poppy, *Argemone platyceras*; the yellow *Menezelia nuda*; the white or pink *Œnothera albicaulis*; *Lupinus argenteus* var. *procumbens*; *Polanisia trachysperma*; *Cleome integrifolia*; *Chrysopsis villosa*; *Asclepias speciosa*; *Croton texensis*; *Eriogonum annuum* and *E. corymbosum*, etc. Also of interest is the little sand cherry (*Prunus pumila*), a low shrub with creeping branches and big, juicy, edible berries. Among the rarer plants I found were *Pectis angustifolia*, *Acerates auriculata*, *Petalostemon tenuifolium*, and another near to *P. gracile*.

I also took a day's ride out to a cañon near North Platte River. The additions to my collection made during the trip contained, among others: *Psoralea linearifolia*, *Eriogonum alatum*, *E. flavum*, *Ribes aureum*, *R. cereum*, *Dalea aurea*, *D. laxiflora*, and *Prunus demissa*.—P. A. RYDBERG, Lincoln, Neb.

ZOOLOGY.

Plathelminthes.—Dr. Braun in Bronn's "Klassen und Ordnungen des Thier-Reichs," Bd. IV., catalogues the known species of ectoparasitic Trematodes. The following species are enumerated from North America: These are *Tristomum maculatum* from *Diodon* sp.; ? *Plectanocotyle elliptica* from *Labrax mucronatus*; *Polystomum coronatum* from *Cistudo carolina*; *Pol. oblongum* from *Dromochelys odoratus*; and *Sphyranura osleri* from *Necturus lateralis*. As soon as our species are systematically studied this list will be greatly increased.

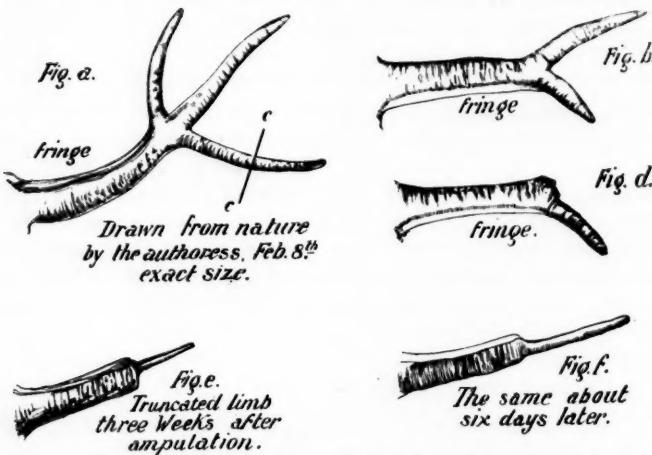
Hermaphroditism in the Crustacea.—Dr. Ishikawa¹ describes the hermaphrodite glands in *Gebia major*. The anterior part of the reproductive organ is male, and the vasa deferentia are much as usual in Decapods. The posterior half of the organ is female, and is much larger than the rest. In sections the germinal band in the testicular portion is seen giving rise to spermatozoa, while in the ovarian part the same band forms eggs. At the point of junction eggs and spermatozoa are commingled. Grobben thinks that these eggs cannot escape through the narrow generative opening, and hence must atrophy at certain seasons of the year. This hermaphroditism was found to occur in all of twenty males examined.

Observations on a Remarkable Development in the Mud-fish.—An interesting example of abnormal development may be seen in some mudfishes (*Protopterus annectens*), now in the Zoological Gardens of London. Eight rather young ones, of from six to eight inches long, were brought to England in the summer of 1889, and have ever since occupied one capacious tank. It was soon seen that they viciously snapped at each other, maiming and nipping off each other's filamentary fins, then about two inches long, but which, however, soon grew again. By degrees, and particularly within the last six months, I observed that, in consequence of frequent mutilation, the fins did not attain their normal length, but were stouter and flatter, less and less filiform, and with a more distinct fringe, as if nature were compensating in breadth what was lacking in length. The fish, being now much grown, snap at each other with greater force. The biggest is nearly two feet long.

During our unusually severe winter my observations were suspended, and I was therefore greatly surprised in February to find that one of

¹ *Zool. Anz.*, XIV., 70, 1891.

the mudfishes had meanwhile developed a trifid member (the left pectoral fin) like the accompanying sketch (Fig. a). The keeper informed me that some weeks previously that fin had been bitten, but not quite severed, about midway, leaving a jagged wound with terminal portion pendant. It had now not only healed, leaving no trace of the wound, but the nearly severed portion had become firm and solid, forming one direct, tapering line from the body. The two lateral segments were, when quiescent, at right angles with the middle fin (or branch?); but



*Abnormal developments in fins of the
 Mud-Fish drawn from life, by
 the Authoress Feb. & March 1891.*

with the movements of the fish they collapsed or expanded freely as might be, and as far as I could decide each one appeared to possess independent action. They were flat, thin, exceedingly pliant and membranous, especially towards the edges; and when the fish was detained in a net out of the water, and I attempted to examine the limb more closely, it was flapped about vigorously, or it clung to the net, and to handle it would have invited a vicious and forcible bite. The segments somewhat resembled the tail of a tadpole.

Another of the mudfishes had grown a bifid fin (Fig. b), though one cannot affirm positively that a portion had not been nipped off before it was observed, for three days afterwards it was already partially gone (Fig. d), and the trifid fin had also been bitten, as at

the lines *cc*. Concluding that these singular developments were worthy the attention of our scientific authorities, I lost no time in sending a description of them to Dr. Günther and Mr. Boulenger, even venturing to suggest that before they were eaten off by degrees a snip of the professional scissors might preserve the specimen for the museum. Mr. Boulenger, in consequence, secured the trifid limb, and in due time the result of his investigations will appear in the Zoological Society's "Proceedings." I observe, too, that the long, vertical fin and also the tail, when bitten, now no longer regain their normal form as they did at first, but remain indented with broad, rounded lobes, and with an indurated edge, like a cord. The whole development strikes one as an example of rapid evolution; as if *Protopterus*, after many fruitless attempts to restore its slender limbs, had "improved" upon them, growing them stouter and stronger to assist it in swimming, compensating in bulk what it could not acquire in length. But this is mere imagination on my part. I must leave to science to account for the anomaly.

The amputated limb healed entirely, with the angles rounded off, in three days. Within three weeks a point (Fig. *e*) grew out from the truncated limb, but not in the center. In a few days more the point was nearly three-fourths of an inch long and more in the center (Fig. *f*). It will be closely watched.—CATHERINE C. HOPELY.

The Lower Jaw of *Sphenodon*.—It seems to me that there has never been given a correct description of the lower jaw of *Sphenodon*. Günther² writes in 1867, in his "Anatomy of *Hatteria*": "A part of the sutures between the bones of which the lower jaw of lizards is generally composed have entirely disappeared (if they ever existed), so that the following bones only can be distinguished. The dentary (*u*) forms nearly entirely the outer surface of the mandible, a comparatively small articular portion, and the top of the coronoid process excepted. There is a very distinct foramen between the dentary and articular, penetrating to the inner surface of the mandible. The splenial (*v*) is narrow elongate, behind twisted downwards to the lower side of the mandible and terminating about three millims. from its extremity. The coronoid (*x*) is triangular, covering with one angle the cartilage of Meckel, and forming with another the coronoid process. The articular bone (*w*) is very peculiar; if an angular bone was present at an early age it has now entirely coalesced with the splenial, there being scarcely any osseous projection behind the articular surface. The articular surface itself does not correspond in form with

² *Philos. Trans.*, 1867, pp. 600, 601, Pl. ~~xxxi~~, Figs. 6, 7.

the condyle of the quadrate bone, being much elongate in the direction of the longitudinal axis of the body, and, in fact, nearly four times as long as the opposite articular surface."

Exactly the same description is given by Brühl:³ "Der Hatteria Unterkiefer setzen wirklich in jeder Hälfte nur vier Elemente zusammen: 1. dentale, d.; 2. articulare, ar.; 3. coronoideum, cor.; mit einen mässigen processus coron.; und 4. marginale, marg. (mihi = angulare autor. = spleniale Owen, Günther); die sonst bei Echsen meist vor kommenden Mehrstücke; 5. ecto-complementare, ec. cp. (mihi = supra angulare autor.) und 6. endocomplementare, en. cp., auch operculare, op., fehlen bei Hatteria spurlos."

In a lower jaw of *Sphenodon* (length of each ramus 56 mm.) I find all the six elements of the Reptilian lower jaw represented. The whole arrangement, however, is only comparable with that seen in the *Testudinata* and not with that of the *Squamata*.

The dentary, coronoid, and angular (splenial Günther, marginal Brühl) are described correctly by both Günther and Brühl. The remaining portion of each ramus is considered as articular. In the specimen before me this portion plainly consists of three elements,—an articular, splenial, and supraangular.

The articular is a small element, only visible from above and very little from behind. It is surrounded by the splenial on the inner and the supraangular on the outer side; it is very much like the corresponding element in the *Testudinata*. The supraangular is that portion of Günther's and Brühl's articular which is seen on the outside and inside. It is connected with the articular, the splenial, the angular, the dentary, and the coronoid. Between this element and the coronoid the foramen is placed. The splenial is the inner portion of Günther's and Brühl's articular. It is connected with the articular, supraangular, angular, and coronoid. We have therefore a condition which is typically that of the *Testudinata*. In all the *Testudinata*, however, the angular separates the splenial and supraangular behind; in *Sphenodon* the splenial and supraangular meet at the posterior lower end of the jaw.

The structure of the lower jaw in *Sphenodon* gives another support to the opinion of the affinity between *Rhynchocephalia* and *Testudinata*.—G. BAUR, *Clark University, Worcester, Mass., April 8th, 1891.*

On the Development of the Male Copulatory Organs in Snakes.—Although the adult anatomy of the male copulatory organs in snakes has been carefully worked out by Neumann⁴ and others, very

³ Brühl. *Reptilienkopf*. Wien, 1886, Tafel p. CXLVIII., Figs. 12, 13, 17, 18, 19, 20.

⁴ Begattungsapparat der Schlangen. Leipzig, 1884.

little seems to be known of their development. Rathke⁵ is, so far as I know, the only one who has studied it; his account deals merely with superficial appearances, and is therefore very incomplete.

I have been able to make out a few points in the early history of these organs from specimens collected in July, 1890, at the Marine Biological Laboratory, at Cold Spring Harbor, Long Island. My specimens were mostly embryos of the black snake (*Bascanium constrictor*), of from the second to the ninth week of embryonic life, together with a few garter snake (*Eutenia sirtalis*) embryos, taken at a considerably later stage in their development.

First, a word on the general anatomy of these organs. The male copulatory organ in snakes, as in lizards, is made up of two distinct parts. Each part is in the form of a long, hollow sack, more or less irregular in outline, and in some species bifurcated at the end. A thick layer of connective tissue, containing numerous cavities in its outer portion, forms the greater part of the walls of this sack. These cavities are connected by a branch with the dorsal artery, and it is by a flow of blood into them that erection of the penis is accomplished.

Outside of this connective tissue is the epithelium, a continuation of that covering the rest of the body. This epithelium consists of two layers. The inner, called by Neumann the "stratum mucosum," is made up of large, columnar cells arranged side by side, and containing prominent nuclei; the outer is a layer of very much flattened cells with deeply staining nuclei, joined by their edges to form a thin covering to the whole.

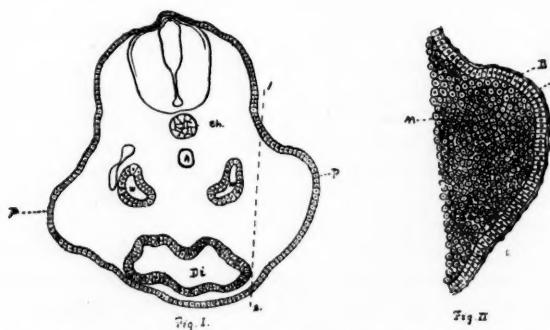
On the inner side of each penis, running obliquely from base to tip, is the *semen canal*. This is a deep depression, approximately anchor-shaped in cross section. During copulation the two parts of the penis are brought together in such a way as to make of these two canals one long tube, which then serves to conduct the semen into the oviduct of the female.

Closely set all over the surface of the penis are numerous cartilaginous teeth-like bodies, which arise in the connective tissue, and project out through the epithelium. Their exact function is not known, though they have been regarded as "wollustorgane," or contrivances for stimulating the sexual organs. It is possible that they may serve to hold the sexes more firmly together during the act of copulation.

These penes arise as external appendages. At the close of embryonic life, however, they are drawn back into two pouches, one on either side of the body just behind the cloaca. This action is effected

⁵ Entwicklung der Natter. Königsberg, 1839.

by a long muscle, the *retractor penis*, which runs from the point of the penis through its interior back for a considerable distance in the tail; there it is attached to one of the caudal vertebræ. The action of this muscle is such as to turn the penis inside out,—as the finger of a glove could be turned,—back into its place under the skin. At times of copulation the organs are everted, chiefly by an influx of blood into their erectile tissue.



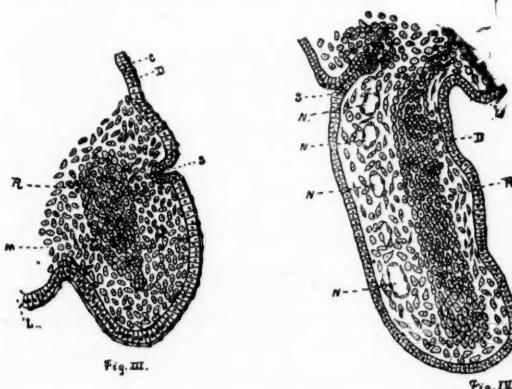
The copulatory organs first appear in embryos of about the sixth week. At this stage most of the important organs of the body are formed; the body has completely closed in, except at the umbilicus, the food-yolk not being entirely consumed until a much later period. The wolffian ducts open into the cloaca, but the ureters have not yet grown so far back.

The first appearance of the penes takes the form of two ridges, one on either side of the body, and extending from a point a little ahead of the cloaca to about opposite its posterior end. In sections across the body at this stage (Fig. 1, δ) these ridges can be seen as bulgings of the body-wall. These bulgings are filled (Fig. 2) with an undifferentiated mass of mesoderm cells, similar to and continuous with those composing the body proper. The whole is covered with the characteristic double-layered epithelium.

The further growth of the penes from these ridges reminds one strongly of the manner of formation of the posterior appendages in the chick, from the end of the wolffian ridge. The extreme posterior end of each ridge swells out, forming a rounded prominence, the "nipple-shaped swellings" of Rathke. The remaining portions of each ridge grow no further, and finally disappear. In embryos of a week later no trace of them is to be found.

These swellings, however, continue to enlarge, and form the penis proper. They grow very rapidly in length, and attain their full size in about three weeks. They are then equal in length to three-quarters the vertical diameter of the body.

Simultaneously with the growth of these swellings a differentiation of the mesoderm cells in their interior begins. The cells near the exterior gradually lose their round form, become more and more angular, their ends prolonged more and more into slender processes,



until, in my latest sections of the black snake, they can be seen to be well on their way toward the formation of connective tissue. Among these cells clear spaces with a regular outline appear (Fig. 4, *n*). These are lined with a layer of flat cells, similar to those Neumann describes as lining the blood cavities in the adult penis. They are the beginnings of the blood spaces, which, with their connective tissue walls, compose the erectile tissue in the adult.

While this change into connective and erectile tissue is going on among the outer mesoderm cells, those on the interior undergo a differentiation which leads to the formation of the *retractor penis*. In embryos of about the seventh week the first rudiments of this muscle may be seen as a thickening or crowding together of the mesoderm cells in the middle of each organ (Fig. 3, *r*). These cells elongate, become nearly elliptical in form, and arrange themselves in rows, thus giving rise to the muscle fibres.

In the adult penis there are two sets of these fibres, a large, inner, longitudinal band, with an incomplete circular band surrounding it.

The separation into two sets of fibres can be readily seen in the manner of grouping of the mesoderm cells. The exact manner in which muscle fibres arose from mesoderm cells, I was, however, unable to determine from my specimens.

Neither semen canal nor cartilaginous "teeth" had been found in the latest of my black-snake embryos, but both were present in the garter snakes. From this I infer that they arise at about the same time, and at about the same stage in the development of the organs. The semen canal is lined with large cells, continuous with those of the stratum mucosum, and is undoubtedly formed by an invagination of the epidermis. The "teeth" are modifications of the connective tissue walls, as Neumann has shown, but the exact manner of this change I could not determine.

Lying behind the cloaca in the adult snake are two cone-shaped glands, with ducts opening to the exterior just behind the cloacal opening. These are the "*anal sacs*," and secrete a sticky fluid, with a highly unpleasant odor. Rathke thinks this odorous fluid enables the sexes to find one another during the breeding season.

These glands occupy, in the female, a corresponding position to that of the drawn-in penis in the male. Hoffmann⁶ quotes Retzius to the effect that they occur only in the female, and are homologous with the male penis. Neumann finds them, though much aborted, in the adult male. In embryos I find them present, and of equal size in both sexes. They cannot, therefore, be considered homologues of the penis. Their ducts open to the exterior in the male,—not, as Rathke states, on the *inner* side of each penis, but on the *outer* side. In the female they open in corresponding positions.

These glands first appear in the embryos of the seventh week. Rathke's statement that they arise as invaginations of the posterior wall of the cloaca does not agree with my observations. In my specimens they were formed by an invagination of the *outer* wall of the body just above the penis (Figs. 3, 4, 5). The gland is formed, as Rathke states, by a continued growth inward of this invagination. Both layers of the epidermis are carried in with it, and enter into the composition of the sac. In the "*grosszelligen Plattenepithel*," which forms its outer coating, Neumann recognizes a transformed stratum mucosum, now exercising a glandular function; in a thin layer covering its inner surface he finds the remnants of the original stratum corneum.—AARON L. TREADWELL, *Biological Laboratory of Wesleyan University, Feb. 6th, 1891.*

⁶ Bronn's *Thier Reichs*, p. 1557.

EXPLANATION OF FIGURES.

FIGS. 1 and 2 are drawn to the same scale. Figs. 2 and 3 are drawn to a scale a little larger than 1 and 4.

FIG. 1.—Section through body of embryo of black snake, in front of the cloaca.

FIG. 2.—Portion of Fig. 1, to right of line 1-2, drawn to larger scale.

FIG. 3.—Right penis of black-snake embryo, two weeks older than Fig. 1. Section passes through body just behind the cloaca.

FIG. 4.—Section of left penis of black-snake embryo, one week older than Fig. 3. Section taken just behind cloaca,

P, ridge which marks first appearance of penis; *ch*, notochord; *a*, dorsal artery; *w*, wolffian duct; *d*, alimentary canal; *m*, mesoderm; *s*, stratum mucosum; *c*, stratum corneum (not figured in 1 and 2); *r*, retractor muscle; *s*, beginning of anal sac; *n*, blood spaces forming in the mesoderm; *l*, edge of posterior wall of cloaca.

The Quadrata Bone.—R. Broom thinks⁷ that all previous morphologists have been in error in trying to recognize the quadrata among the bones of the middle ear of mammals. He thinks it forms the articular cartilage.

"Some of the Causes and Results of Polygamy Among the Pinnipedia."—In the February number of the AMERICAN NATURALIST (Vol. XXV., pp. 103-112), Mr. C. C. Nutting has published some interesting notes on sexual disparity among polygamous seals, and deductions from the observations recorded. Mr. Nutting, however, was not the first to draw attention to such facts and the principles involved. Over twenty years ago (January, 1871) the subject was noticed, and the resulting conditions tersely formulated in the AMERICAN NATURALIST (Vol. IV.). In a review of Mr. Allen's then recent memoir on the eared seals I published the following paragraph immediately after one on the genetic relationships of the families of Pinnipeds:

"In this connection it may be recalled that while in the monogamous Pinnipeds, or those living in small communities, there is little difference in size between the males, in the social species, or rather those of which the males have harems, the males are vastly larger than the females. *Macrorhinus*, of the Phocids, and all the Otariids belong to the latter category. The difference between the sexes would be readily explained by Mr. Darwin on the principle of natural selection. It is evident that the larger and more vigorous males would be the eventual possessors of the females, and the disproportion of the sexes

⁷ *Ann. and Mag. Nat. Hist.*, VI., 409, 1890.

would in lapse of time culminate, till it had reached a proportion when obvious mechanical difficulties would more than balance the advantages resulting from superior size and vigor, and when, therefore, farther disproportion would be arrested. It may be added that the like disproportion of the sexes in the forms above enumerated furnishes not the slightest evidence of more intimate primordial affinity, for like causes would in each special case, such as this, produce like effects."—THEODORE GILL.

Errata of article on Chromatophores in fish embryos in February NATURALIST: Page 113, 9 lines from bottom, read oviparous for viviparous; page 114, 15 lines from top, read periblast for epiblast; page 116, 16 and 29 lines from top, read periblast for epiblast; page 117, 25 lines from top, read periblast for parablast; page 118, 2 lines from bottom, read *Hemirhamphus* for *Hemishamphus*.—C. H. EIGENMANN.

EMBRYOLOGY.¹

The Later Larval Development of *Amphioxus*.²—Mr. Arthur Willey has published a most interesting account of the later stages of the larval *Amphioxus*. It is a continuation of a preceding paper by Professor Lankester and himself on the younger larva. In the first paper the larva, with its large mouth on the left side and the single row of gill-slits on the right, was described; also the structure and position of the club-shaped gland and the endostyle were given, and the origin of the atrial folds. In the present account the author begins with a larva having fourteen primary gill-slits arrayed in a single row, and all on the right wall of the pharynx. Above these and on the same side is to be seen a thickened rod of endodermal tissue with six swellings. These later break through to form six secondary gill-slits, second to seventh inclusive. The atrium is still open in front. The posterior primary gill-slits now begin seriatim to close and atrophy, beginning with the fourteenth and continuing until but eight remain. At the same time this primary row of gill-slits begins to move around the ventral surface to the opposite side of the larva (the left), where they assume their adult position. Meanwhile the secondary gill-slits increase in number and size, and occupy the right side of the

¹ Edited by Dr. T. H. Morgan, Johns Hopkins University, Baltimore, Md.

² *Quart. Jour. Micro. Sci.*, March, 1891.

embryo. A single anterior (to the six) slit appears, and others are also added behind the first-formed slits, ultimately the number of eight secondary gill-slits being formed. There is then a pause for a time in the formation of slits, and much later the tertiary slits appear behind on each side, and the number goes on increasing during life.

While these changes have been taking place in the gill region other important organs have been modified. The mouth has moved from its left lateral position to the mid-ventral line, and the oral hood with its buccal cirri has appeared. The V-shaped endostyle, at first high up on the right wall of the pharynx, moves as the primary gills move, from right to left, as far as the middle line, and at the same time the arms of the V become parallel, and the apex grows backwards between the gill-slits. The club-shaped gland, which communicates both with the cavity of the pharynx and the outer world, atrophies, and at the same time also the first primary slit. For this or other reasons the author believes the club-shaped gland to be a modified gill-slit,—the first of the secondary ones.

In the theoretical part of the paper the asymmetry of the larva, the change of position of the endostyle, and the homologies of the club-shaped gland, are discussed. Interesting as this excursion is, it cannot be given here at all fully. It is assumed that the ancestral *Amphioxus* had a mouth opening in the mid-dorsal line, and that the growth forward of the notochord caused this to shift to the left side. At the same time the whole pharynx became twisted to the right, corresponding to the movement of the mouth, so that the proper gill-slits of the left side were carried around to the right side. Consequently when these (the primary) appeared the gill-slits belonging to that side (right and secondary) were for a time retarded in development; hence the asymmetry of the larva.

Several sections deal with the homologies between the Ascidian tadpole larva and *Amphioxus*, and the startling conclusion is reached that the intestine of the Ascidian is not homologous with the intestine of *Amphioxus*, but is to be compared to the club-shaped gland, and therefore represents the modified first right (secondary) gill-slit of *Amphioxus*.

Development of the Pancreas in Batrachia.—The origin of the pancreas in both Urodeles and Anurans has been studied anew by Göppert.³ In the embryos of both groups the pancreas arises by three evaginations from the intestine. One of these is from the dorsal surface; the other two from the sides, right and left. The

³ *Morph. Jahrbuch*, XVII. Band, 1st Heft, 1891.

cells of these evaginations fold in and form the tissues of the pancreas. The three portions separated at first subsequently fuse into a single organ. The three openings into the gut, however, undergo several changes. In the adult Urodeles there is a forward opening for the pancreatic gland into the intestine near to the pylorus. This comes from the dorsal evagination of the embryo. There are in the adult Urodeles two or more other openings behind this, some of which fuse with the duct from the liver (ductus choledochus). The posterior openings result from various combinations of the two ventral (right and left) evaginations. In the Anuran the adult has no anterior opening of the pancreas near the pylorus. In the embryo, however, there is one (the dorsal), as in the Urodeles, but it is subsequently lost. The two ventral (or side) evaginations unite with one another and form a single opening, which subsequently fuses with that of the ductus choledochus, as in the adult.

Embryology of Glires.—M. Duval has published another of his series of papers on the development of rodents, entitled, "Le Placenta des Rougeurs."⁴ The young stages of the mouse are described. Sections through the whole gravid uterus were made in most cases. The earliest stage described had a single layer of ectoderm cells surrounding a central cavity. Underneath one portion of this layer were a very few large granular amoeboid-like cells, which subsequently spread out beneath the ectoderm to form the endoderm lining of the vesicle. Above this portion in later stages the ectoderm thickens greatly, resulting in a solid plug in which a cavity subsequently appears to form the cavity of the amnion and the ectoplacenta. The relation subsisting between this ectoplacenta and the allantois on the one side and the uterine walls on the other form the substance of the latter part of the paper. The problem of the inversion of the layers in the mouse and rat were discussed in a preceding paper (see abstract in *AMERICAN NATURALIST* for April, 1891).

⁴ *Journal de l'Anatomie et Physiologie*, Jan.-Feb., 1891.

ARCHEOLOGY AND ETHNOLOGY.¹**The International Congress of Anthropology and Prehistoric Archeology of Paris, 1889.**—(Continued from page 395.)

II.—*Second Question*: “The Periodicity of Glacial Phenomena.”

Mr. Geikie's paper had been read earlier in the session.

Marquis de Saporta opposed the theories of Mr. Geikie. He saw no evidence in the fossil flora of a periodic return of the cold climate. The periodicity of this phenomena, according to his idea, only showed the oscillations. “There is,” he said, “in all this a mass of concordant facts which we are at this time far from being able to understand or analyze.” He doubted whether the learning of the geologists had served to elucidate the question in any degree.

Le Docteur Garrigou presented a memoir by which he sought to establish the multiplicity of glacial movements in the Pyrenees.

Monsieur Marcellin Boule said it was necessary that the savants of all countries should make study of this question, and bring closer together and face to face the accurate evidence of detailed facts which were necessary to solve the problem. In his opinion the Glacial epoch had commenced at least as early as the Pliocene; that it was not localized, nor did it belong to the end of the Pliocene. The glaciers had successively covered and abandoned, and again recovered, vast regions, and instead of being continuous were periodic. The question could be solved only in a general fashion, but he desired to put on record his opinion that the question of the glaciers, the cutting and filling of the valleys, and the formation of the caverns all belong together, were but one, must stand or fall together, and any studies made of the one which neglects the other will only be partial, and therefore may be erroneous. His (Boule's) conclusions regarding the caverns were as follows: 1. That the most ancient deposits are the alluvials of the water which had eroded and made the valleys, and that the antiquity of these deposits was in direct relation to the altitude of the cavern above the valley. 2. That the deposits of the rivers, poor in fossils, are nearly always cut up, carried down, and replaced by new deposits coming from later erosions. 3. That the fossils found in this newer deposit belong to the late Pliocene; those from the earlier Pliocene are rarely found in it; and such as are found are, by reason of the erosion and redepositing, difficult to determine.

¹ Edited by Dr. Thomas Wilson, Smithsonian Institution, Washington, D. C.

Monsieur Gabriel de Mortillet spoke of the glacial phenomena as being divided into two groups: the one at the far north, and the other in the Alps, Pyrenees, etc., in the south. The Alps and glacial phenomena could have been produced by only one cause, that of the increased cold, and this cause would at the same time produce an extension of the glaciers of the north. He might admit the fluctuations, oscillation, retreat and advance, appearance and disappearance of the glaciers, but this was far from admitting a plurality of glacial periods, and was contrary to this idea.

M. Marcellin Boule took up the question and gave a detailed description of European glaciers. After late investigations the epochs of the glaciers of the north and of the Alps could not be separated, and geologists were not in accord in opposing the ancient hypothesis of the Pliocene sea of floating ice. The grand glacier coming down and through Scandinavia had attained to Erzgebirge, where it had deposited erratic blocks *geschickelehm*. This was followed by a retreat corresponding to the melting and opening of the North and Baltic Seas, during which time was deposited the interglacial alluvium, with a fauna of a warm country. Alluvium deposits of this epoch were so extensive that they measured in Brandenburg alone a surface of 200,000 square miles, German. In the Alps the deposits of interglacial plant at Innsbruck are found at 1,000 metres of altitude, at the very top of the chain of mountains. As for paleontology, M. Boule declared that the stratigraphic facts must dominate, though he doubted the pretended facts of stratigraphy as given by some of the investigators, though he was far from saying that the fauna and flora of the Upper Pliocene, the Pliocene, affected detrimentally or were in opposition to the facts found by stratigraphy. MM. Bleicher and Fliche have just described to the Geologic Society of France a deposit in the northeast of France, in the plants and mollusks demonstrating the alternating epochs of cold and heat.

Third Question: "Art and Industry during the Paleolithic Period—in the Caverns."

Judge Piette, of Angers, who probably headed the list of cavern investigators in France, had displayed at the great exposition his magnificent and extensive collection, principal among which were his late finds in the cavern of Mas d'Azil, on the river Avise, in the Department of Ariège, and so he was entitled par excellence to lead in the discussion. He gave a description of these latest discoveries, the results of three years' continuous labor in Mas d'Azil, and presented his opinions and conclusions deduced from a study and comparison

of the art works of the period. He said that the most ancient pieces of flint were worked in an elegant form ; a perception of the beautiful was evident. There was an extension of art during the Madelenien epoch ; the sculpture first, and engraving afterwards. Each prehistoric station in that country had its particular style or manifestation of art. Along the river Vezere the horses engraved in relief are represented with such enormous heads as to be veritable caricatures. In the Pyrenees, at the Grotte Gourdan and Lortet, numerous beautiful engravings were found. The artists of Lourdes and the Grotte Arudy had invented the volute, the spiral, and different designs which were not encountered at any other place. The sculptors of Mas d'Azil sought out imaginary, apparently mythological beings. Man at that time had the leisure to pursue his own imagination, the opportunity to indulge his love for the beautiful according to the best means that art presented. M. Piette presented different engravings of the reindeer in certain positions and conditions sustaining his theory. He also exhibited the advance sheets of his great work on art during this age, and showed by chromo-lithography the reproduction of a great number of objects engraved and sculptured.

M. Montelius asked if the spiral exhibited by M. Piette as from d'Arudy did not belong to the age of iron ; that it would be so if found in his country.

M. Cartailhac responded on behalf of M. Piette that he had assisted in its find ; that there was no doubt of its authenticity ; that it was made out of the bone of a reindeer, and its contemporaneity with that age was indisputable.

One of the objects presented by M. Piette he declared to be a sphinx or winged quadruped. Le Baron de Baye was surprised that it was found in a deposit of the stone age. But M. Cartailhac responded that it required much imagination to determine or say that it was a sphinx. It was incomplete, and the wings were more than doubtful, and he denied largely the propositions advanced by M. Piette, though praising him for his exceedingly valuable excavations.

M. Gabriel de Mortillet also opposed the hypothesis of M. Piette upon the subject of the demonstration of the reindeer and the horse.

Monsieur Fraipont ranged himself on the side of Mortillet, and he criticized mercilessly the fantastic idea that the artist studied art in the same way that the schools were now conducted at the Academy of Beaux Arts, or in the studios of the great painters of Paris. He declared it to be a common error which substituted for the prehistoric man the cultivated, educated artists of the nineteenth century, making the

primitive man to look at art through his eyes, and to study it with his critical or æsthetic eye, as though the primitive works were to be submitted to the committee for entrance into the great Salon of Paris. He declared this to be not scientific nor even sensible, but to be in the highest degree fantastic ; that the sooner it was laid away, and the students and archeologists of to-day come down to common ground, and devote themselves to presentation of the actual facts, the better it would be for the science. He ridiculed the idea put forth by M. Piette that these artists of the paleolithic age made studies and executed sketches of skeletons, whether of man or beast, for the same reason as do our modern artists,—that is, to study the anatomy and be better able to render correctly the form in the flesh. "No," said he, "the artist of Mas d'Azil copied the heads which may have been skinned or flayed, and the bare bones of the skull or skeleton which he may have had many times before his eyes."

M. Piette responded. He demanded the proofs that the domestication of the reindeer was impossible without the dog. He declared his belief that the engravings of the woman and the reindeer constituted a true picture, of which we now unhappily have but part. The lines of the two subjects do not penetrate or interfere with each other ; the legs of the reindeer, as they cross the picture of the woman, are brusquely interrupted, while the lines depicting the woman continue across. It is the case of the one object being represented behind the other.

Mr. John Evans said the interpretation of a few designs slightly obscure is not sufficient proof that the reindeer and other animals were domesticated. The dog would appear to have been the first animal domesticated, and this was in accordance with logic and reason.

Monsieur Delgado made an elaborate, detailed, and interesting communication upon a series of prehistoric caverns found in Portugal. They had served as habitations and also as burial places. The objects of human industry were of worked flint, arrow, and spear-heads, flasks, pottery, polished stone hatchets, worked bones, ornaments, etc., interspersed with weapons or tools and ornaments of bronze. They were the same race apparently, so far as could be judged from the human remains, as had been found in the south of Portugal and Spain. The skull was dolichocephalic, and the tibia platynemic.

Question III. had a second part : "The Value of Paleontologic and Archeologic Classifications as Applied to the Pliocene Period."

Doctor Gosse, of Geneva, presented charts of Lake Geneva showing the various deposits along its banks made during the Pliocene period,

and attempted to show the relations between them and the various ages of man as manifested by the fauna of the mammoth, then of the reindeer, and finally of historic times. He showed a Chelléen instrument coming from a deposit of the time of the mammoth, from one of the highest (altitude) localities.

M. Amerano, Superior of the College of Finalmarini, Liguria, described his discovery at the station occupied by prehistoric man in the cavern of the de la Fée in that neighborhood, and 300 metres above the sea-level and one-and-a-half hours distant. He found in a single day, within the space of four cubic metres, six entire heads of the cave bear, twenty large fragments of others, eighty under jaws, one hundred and ten teeth, etc., representing no fewer than fifteen hundred individuals. There were two human occupations in this cavern; the earliest and lowest contained objects of human industry which Monsieur Reviere thought were similar to those of the most profound depths of the Grottes de Menton. The upper and later was entirely neolithic, with polished stone hatchets, grinding stones, and a piece of copper or bronze.

The Mexican Tonalamatl of the Aubin collection, and the other calendars related to it, have been investigated by Dr. Edward Seler, and described in the "Compte Rendu du Congrès International des Américanistes," seventh session, Berlin, 1888, his illustrated report filling not less than 219 octavo pages. The tonalamatl is a representation of the Mexican astrologic year of 260 days, and exists in several copies, differing considerably from the copy once in the possession of the French collector, Aubin. They represent heads of gods and genii, which are ornamented in various ways with symbols, and arranged in squares. Before we can understand these astrologic calendars we have to discover which god or genius is meant in every instance, and to this task Seler's pages are devoted, for the Spanish texts accompanying the pictures are not always clear enough. The erudition which Seler brings into play is astonishing, and only a close comparison of his interpretation with the published pictures can convey to us an understanding of the astrologic art of the Mexican people. This article is composed in German, as is also another publication of his, "Alt-mexicanische Studien," published in the "Veröffentlichungen aus dem Königlichen Museum für Völkerkunde," Vol. I., No. 4, fol., Berlin, 1890. The first of Seler's articles treats learnedly of "A Chapter from the Unpublished Aztec Materials Supplementary to the 'History' of Father Sahagun"; the second deals with "The So-called Sacral Vases of

the Zapotec Indians." These meritorious antiquarian inquiries of the Berlin savant are profusely illustrated with wood-cuts in such manner that the original colors are made apparent from the drawings.—A. S. G.

Huastec Language.—Reliable information upon this language of Eastern Mexico is not easily obtainable. We notice with agreeable surprise that a treatise of considerable extent has just been published by a native of that country, by the Statistical Bureau of Mexico. The title runs as follows: "Cartilla huasteca con su gramatica, diccionario, y varias reglas para aprender el idioma, etc. por Marcelo Alejandre, Mexico, Calle de San Andrés, numero 15, 1890. Quarto, pp. 179." The Huastec language is the northernmost of the Maya dialects, and differs very considerably from all others in the lexicon and in the grammatical portion. This difference is ascribed by linguists to the archaic character of the language, but other causes may also have been at work. The nouns do not inflect for case, but for number only; for the verb the author establishes two conjugations, according to the suffixes which are employed in forming the preterit tense. The personal pronoun is placed separate from the verb. The dictionary, by Lamberto Asiaín, contains about 2900 items, and is supplemented by a Spanish-Huastec part. There are two principal dialects of Huastec, the Potosino and the Veracruzano; they are spoken at Tantoyuca, Chontla, Tantima, Amatlan, San Antonio, Tancoco, and are heard sporadically also at Ozuluama, in the state of Vera Cruz, where Alejandre composed his Cartilla or elementary manual. The volume concludes with some specimens of conversation and poetry in that language, and makes mention of historic traditions once current among the ancestors of the present Indian population.—A. S. G.

Zapotec Language.—The Licentiate Francisco Belmar, of Oajaca, has composed a juvenile manual for the study of the mountain dialect of the Zapotec, which is spoken in the central parts of the state of Oajaca, Mexico. The thirty pages of the little book are filled with Zapotec words, arranged after the number of syllables which they contain, and with their Spanish definitions; the book concludes with some religious short texts, and although the translation is not added to these, the lexical portion of the Cartilla, which was published in Oajaca, 1890 (16mo), will be of service to the students of linguistics at large.—A. S. G.

Mixtec and Mije are two aboriginal nations of Oajaca, Southern Mexico, which have retained their Indian languages in a comparatively

pure condition up to the present epoch. Mixtec is spoken in the western and northern parts of Oajaca, and also in the adjoining portions of the state of Guerrero, and is closely related to the Chuchon, Amusgo, Cuitlatec, and other idiomatic forms of speech heard in these parts. The Mixtec proper is divided into upper and lower Mixtec, the majority of the Pueblos speaking the upper Mixtec, or Mixteco alto. In former times the Pueblos of Tanguitlan and of Tepuzculula were considered to speak the typical and purest form of the upper Mixtec. The Spanish grammar (Arte) of the Dominican father Antonio de los Reyes, printed in 1593, represents the dialect heard at Tepuzculula at that time, and has just been reedited by Leon Reinisch, at the expense of Count Hyacinthe de Charencey, in the eighteenth volume of the "Actes de la Société Philologique de Paris," 1890, making 93 octavo pages. The prologue which precedes the work (eight pages) contains much that is valuable upon the ethnography and dialects of the Mixtec people.

The same eighteenth volume contains a Confessonario en lengua Mixe, by the Dominican father Augustin de Quintana, also republished at M. de Charencey's expense, and filling 331 pages. It is a reprint from the edition of LaPuebla, Mexico, 1733, and besides the devotional texts embodies a vocabulary of the parts of the human body, the names of relationships, the numerals, and some grammatic information. Mije or Mixe is spoken in the eastern parts of Oajaca State.

—A. S. G.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

The National Academy of Sciences met at Washington April 21st. The following papers were read: Further Studies on the Brain of *Limulus polyphemus*; A. S. Packard. On Aërodromics; S. P. Langley. The Solar Corona, an Instance of the Newtonian Potential in the Case of Repulsion; F. H. Bigelow (introduced by S. Newcomb). Report on the Human Bones of the Heminway Collection in the U. S. Army Medical Museum, prepared by Dr. Washington Matthews, U. S. A.; J. S. Billings. Application of Interference Methods to Spectroscopic Measurements; A. A. Michelson. The Corona from Photographs of the Eclipse of January 1st, 1889; H. S. Pritchett (introduced by A. Hall). Stellar Motion Problems; Lewis Boss. Effect of Pressure and Temperature on the Decomposition of

Diazo-Compounds; Ira Remsen. Researches on the Double Halides; Ira Remsen. Allotropic Silver; M. Carey Lea (introduced by Ira Remsen). Note on a Paper by M. G. Lippmann; M. Carey Lea (introduced by Ira Remsen). On the Yttrium Earths, and a Method of Making Pure Yttrium; H. A. Rowland. Report of the Watson Trustees, and Presentation of the Watson Medal to Professor Arthur Auwers, of Berlin. On the Distribution of Colors in Certain North American Reptiles; E. D. Cope. The Taxonomy of the Apodal Fishes; Theodore Gill.

Francis A. Walker, of Boston, was elected vice president to fill the vacancy caused by the resignation of Professor S. P. Langley. The Watson gold medal and \$100 in gold were presented to the German Minister, to be forwarded to Dr. Arthur Auwers, of Berlin, in recognition of his work in determining the positions of the fixed stars. The following gentlemen were elected foreign associates: Dr. Karl Gegenbaur, of Heidelberg, and Dr. Jean Servais Stas, of Belgium.

Biological Society of Washington.—April 4th, 1891.—The following communications were read: Kennerley's Salmon; Dr. T. H. Bean. Remarks on Recent Bacteriological Progress in the Prevention and Cure of Disease; Dr. Theobald Smith. Production of Immunity in Guinea Pigs with Sterilized Cultures of Hog Cholera Bacillus; Dr. V. A. Moore. On the Classification of the Apodal Fishes; Dr. Theo. Gill. A Monograph of the Carolina Parrakeet; Mr. E. M. Hasbrouck.

April 18th, 1891.—The Recent Introduction of Date Palms; Mr. H. E. Van Deman. Recent Observations on a Bacterial Disease of Oaks; Mr. B. T. Galloway. Some Florida Plants; Prof. L. F. Ward. Practical Value of Investigating Parasites of Live Stock; Dr. Cooper Curtice. Abnormal Flowers in Glyceria; Mr. Theo. Holm.—**FREDERIC A. LUCAS, Secretary.**

SCIENTIFIC NEWS.

The Boston Marine Biological Laboratory makes the following announcement for its fourth season:—Corps of instructors: Director, Dr. C. O. Whitman, Professor of Zoology, Clark University, editor of the *Journal of Morphology*; E. G. Gardiner, Instructor in Zoology, Massachusetts Institute of Technology; J. Playfair McMurrich, Docent in Zoology, Clark University; T. H. Morgan, Bruce Fellow, Johns Hopkins University; W. M. Wheeler, Fellow in Biology, Clark University; H. C. Bumpus, Assistant Professor of Zoology, Brown University; W. M. Rankin, Instructor in Zoology, Princeton College. Ryoche Takano, Artist; G. M. Gray, Laboratory Assistant; J. J. Veeder, Collector.

In addition to the regular courses of instruction in zoology, botany, and microscopical technique, consisting of lectures and laboratory work under the direct and constant supervision of the instructors, there will be two or more courses of lectures on special subjects by members of the staff. One such course of six lectures will be given by Dr. McMurrich on the Ctenophora and the Turbellaria. Similar courses on the Mollusca, Crustacea, and Echinodermata will be given by Professor Bumpus and Dr. Rankin.

The laboratory is located on the coast at Wood's Holl, Massachusetts, near the laboratories of the United States Fish Commission. The building consists of two stories,—the lower for the use of teachers and students receiving instruction, the upper exclusively for investigators. The laboratory has aquaria supplied with running sea-water, boats, a steam launch, collecting apparatus, and dredges; it is also supplied with reagents, glassware, and a limited number of microtomes and microscopes. By the munificence of friends the library will be provided henceforth not only with the ordinary text-books and works of reference, but also with the more important journals of zoology and botany, some of them in complete series.

The laboratory for investigators will be open from June 1st to August 29th. It is fully equipped with aquaria, glassware, reagents, etc., but microscopes and microtomes will not be provided. In this department there are fourteen private laboratories supplied with aquaria, running water, etc., for the exclusive use of investigators, who are invited to carry on their researches here, free of charge. Those who are prepared to begin original work, but require supervision, special sugges-

tions, criticism, or extended instruction in technique, may occupy tables in the general laboratory for investigators, paying for the privilege a fee of fifty dollars. The number of such tables is limited to ten. Applicants for them should state precisely what they have done in preparation for original work. For the completion of any considerable piece of investigation, beginners usually require from one to three full years. It is not expected, therefore, that the holders of these tables will finish their work in a single season. The aim is rather to make a secure beginning, which will lead to good results if followed up between sessions and renewed, if need be, for several successive years.

The laboratory for teachers and students will be opened on Wednesday, July 8th, for regular courses of seven weeks in zoology, botany, and microscopical technique. The number admitted to this department will be limited to thirty, and preference will be given to teachers and others already qualified. By permission of the director, students may begin their individual work as early as June 15, without extra charge, but the regular courses of instruction will not begin before July 8th.

Rooms accommodating two persons may be obtained near the laboratory, at prices varying from \$2.00 to \$4.00 a week, and board from \$4.50 to \$6.00. By special arrangement, board will be supplied to members at The Homestead at \$5.00 a week.

Applications for places in either department should be addressed to Miss A. D. Phillips, secretary, 23 Marlborough Street, Boston.

Laboratory of Marine Biology of the University of Pennsylvania.—The University of Pennsylvania, though the liberality of Mr. Chas. K. Landis, will be enabled to occupy a modest laboratory building the coming season at Sea Isle City, New Jersey. A building 80 x 24 feet will be provided with places for advanced workers and students, and with an equipment of aquaria for the purposes of biological study. Larger aquaria will be operated for the purpose of displaying to the public the character of the living marine forms found in the immediate vicinity. It is provided that a biological director and staff shall control the workings of the laboratory. While popular or elementary instruction will be given, it is intended that the place shall be mainly a laboratory of research. With this object in view, it is intended, as soon as possible, to throw open its facilities to all biologists of repute, American as well as foreign. It is hoped that the establishment may be got under way by the first of July, 1891, at the latest.

While the location on the New Jersey coast is not as rich faunally as that of New England, it is believed that certain counterbalancing advantages will be gained. One is the accessibility of the location, being only two hours by rail from Philadelphia.

Friedländer's *Naturae Novitates* for May, 1890, advertises under *Vermes*: "Thomas, C. The Circular, Square, and Octagonal Earth-worms of Ohio."

Judging from the plates in the Proceedings for 1890, the new addition to the Academy of Natural Sciences of Philadelphia does not make an architectural unity with the older portion.

Dr. E. Koken, of Berlin, has been elected ordinary professor of mineralogy and geology in the University of Königsberg.

Dr. M. Braun, of Rostock, has been made ordinary professor of zoology in the University of Königsberg.

Col. N. S. Goss died at Neosho, Kansas, March 11th, 1891. He is best known through his papers on the birds of his adopted state.

Professor E. Ray Lankester has been appointed professor of zoology in the University of Oxford. His former position in the University College of London is filled by Mr. W. F. R. Weldon.

Professor O. Frass has been appointed conservator, and Dr. Lampert second conservator, of the Royal Museum of Natural History, at Stuttgart.

The following choice bit of science is from Atkinson's translation of Ganot's "Éléments de Physique," page 5. It *illustrates* the divisibility of matter: "Blood is composed of red flattened globules floating in a colorless liquid called serum. In man the diameter of one of these globules is less than the 3,500th part of an inch, and the drop of blood which might be suspended from the point of a needle would contain about a million of globules. . . Again, the microscope has disclosed to us the existence of insects smaller even than these particles of blood; the struggle for existence reaches even to these little creatures, for they devour still smaller ones. If blood runs in the veins of these devoured ones, how infinitesimal must be the magnitude of its component particles!" . . . "It is hardly necessary to remind the reader that an insect is an insect, whether it is an unhatched egg, a growing larva, an apparently lifeless pupa, or a flying or creeping imago."—*Entomological News*, Vol. I., p. 86, 1890."

Recent Deaths.—Dr. J. J. Friano, botanist, at Paris, Oct. 31st, 1890; E. T. Atkinson, entomologist, at Calcutta, Sept. 15th, 1890; Mathias Auinger, paleontologist, at Vienna, Oct. 11th, 1890, aged 80 years; W. J. Stephens, Pres. Linnean Society, N. S. Wales, Nov. 22d, 1890, at Sydney; James Croll, author of "Climate and Time," at Perth, Dec. 15th, 1890; A. Stoppani, geologist, at Mailand, Italy, Jan., 1st, 1891, aged 60 years; John Marshall, anatomist, at London, Jan. 3d, 1891, aged 70 years; Adam Handlersch, dipterologist, in Vienna, Mar. 24th, 1890, aged 27 years; Otto von Meske, lepidopterist, in Albany, N. Y., Aug. 13th, 1890, in his 53d year.

Prof. C. L. Herrick, of University of Cincinnati, announces the establishment of a quarterly periodical in the interests of the comparative study of the nervous system, entitled *The Journal of Comparative Neurology*. It is the object of *The Journal of Comparative Neurology* not only to afford to those laboring in this direction an avenue for the publication of more descriptive papers than could find a place in other journals, but to supply a brief summary of the foreign literature of this department.

The nominal dates of publication will be March, June, September, and December, but fasciculi will be issued at more frequent intervals whenever material is ready. Thus it is hoped that the publication may combine some of the advantages of a bi-monthly with the greater detail of a quarterly.

Each volume will contain about 500 pages. The annual subscription price has been fixed at \$3.00, or \$2.50 if paid in advance. Separate fasciculi will be sold at an approximately uniform rate of one cent per page and five cents per plate contained.

While the majority of the articles will be original, due attention will be given to technique and the discussion of the more suggestive current papers.

The first volume will contain, among other things, a full account of the histology of the brain of the opossum, a paper on the histology of the Avian brain and the taxonomic value of the brain in birds, a résumé of the recent results obtained by the application of Golgi's method, comparative histology of reptilian brain, suggestions as to the architectonic of the cerebellum, etc., etc. The coöperation of all interested in this department is earnestly solicited. The first fasciculi will follow in the course of a few weeks.

